ENGINEERING

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Parliamentary Answer

THE aircraft industry will remain in the van of British engineering. That much, at most, is clear from the Minister of Supply's statement this week on the Government's future policy for the industry's research and development. Recognising the industry's "valuable contribution to the general economy of the country and to technological progress over a wide field of industry," the Government intend to continue making a financial contribution to aeronautical *research* in the expanding field of civil transport, and will consider individual applications for help in the *development* costs of future generations of civil aircraft.

Just how this interim assistance will work out in detail remains to be seen. The Government are determined to see the industry doing as much as it can to help itself. As the Minister stated, "the Government have taken this decision in the expectation that in course of time the industry itself will progressively assume financial liability for civil research." During the next few years, therefore, the aircraft makers will be obliged to develop their independence. The Government believe that it would be fruitless to continue financial support "unless the industry reorganises and strengthens itself to the extent necessary to meet the changed conditions with which it is now faced."

In fact, the industry has already made positive moves in this direction, though the delay in the announcement of Government intentions must have hindered the industry's policy makers. The special ENGINEERING report on the British aircraft industry, published in last week's issue of this journal, showed that the industry is not, as might be supposed, a collection of a small number of firms engaged exclusively on aircraft work. The pattern is very complex, with ramifications in many other branches of engineering, and the industry as a whole is a vast national laboratory. If the Government's policy had been one of ruthless economy, the effects would have spread to other industries, and adversely influenced both business and technical progress.

Though there has been a reduction in defence demands, and although the Government expect the size of the industry to contract, "there will still be a need for an efficient and economic industry to meet the Services' requirements for aircraft and guided weapons." Aeronautical research and development for defence purposes will therefore continue to be sponsored and financed by the State. But even armaments work is not wholly a Government responsibility; some of the aircraft groups have previously, and are now, developing certain armaments as private ventures. In civil aircraft, Government support has been mostly indirect, through defence research. Much of the best work has been done privately by the firms themselves, and there can be little doubt that, provided the industry can raise the capital, and provided the world's airlines have enough money to spend on machines of advanced design the enforced independence of the aircraft makers should encourage a shrewder approach to future policy. The rate of technical development, however, is not likely to be as fast in the future as it has been in the past. Much depends on the extent to which the United States Government assists their aircraft industry, and whether British interests can exert a stronger influence in the fixing of the international passenger fare structure. At the present time all the operating and commercial potentialities of some advanced British airliners cannot be used to full advantage because the fixing of the fare structure is dominated by American interests.

Fundamentally, the Government's statement is a rather guarded vote of confidence in the aircraft industry. In a broader sense, it is also a vote of confidence in the power of our engineering industries to guarantee the future prosperity of the country, because the Minister specifically referred to the aircraft industry's contribution to technological progress over a wide field of industry. It is not, however, the clear statement of policy which last week we suggested the firms were hoping for. The onus has been put on the firms themselves—which is precisely the policy we would hope a Conservative Government to pursue. But the industry must beware of its research being increasingly carried out by Government laboratories; it must recognise, too, the difficulties that will face the Minister when he receives unco-ordinated applications for development assistance.

Everyone in the industry faces a testing time. On their present showing, they are well able to adapt themselves and meet the challenge. The Government have given them a breathing space, and no doubt there will be further announcements of collaboration and integration in the coming months. In return, the industry's leaders can reasonably ask the Government to interpret the detailed application of their policy as far ahead as possible, because in this kind of engineering plans are laid for many years hence. There must be no chopping and changing. So dynamic an industry is not looking primarily for security; it is looking for good faith and a firm foundation.

Cover Picture. *The sliding velocity between worm threads and the teeth of worm-wheels is greater than with other gearing, so special attention must be paid to the tooth form, the choice of materials and lubricant if high loads are to be transmitted.*

* * *

Plain Words

Physical shocks and emotional shocks—we've all had experience of them. But what about intellectual shocks? The first that I can remember was as a fifth-former when we were being instructed in the mysteries of the differential calculus. All the truths of mathematics which I had absorbed seemed to be outraged by the concepts of calculus. I had to try and wipe out some of the things I had learnt and had come to trust. I was desperately upset for several weeks, because I loved mathematics. Then the mist disappeared, I felt firm ground under my feet again and the landscape of mathematics was richer than it had ever been.

The intellectual shock I experienced a few days ago was of a different kind. I had for long believed that as engineering became more of a science and less of an art, so the craftsman was kept more firmly in his place and the professional engineer did all the thinking and planning. An engineer I know expressed it rather neatly: "We must take the black magic out of engineering and look to engineering-science for the methods and techniques." He is quite right, of course. Then I visited a small works in Mitcham, Surrey, where about 300 men are employed on some of the finest precision engineering that I have seen for a long time. Their special skills are in sheet-metal work, medium and heavy fabrication, machining and precision assembly, and they make such highly complex components as sub-assemblies of gas-turbine aero-engines. They have to work some of the difficult modern alloys and steels—pressing, wheeling, welding and so forth. Much of their work is sub-contracted from the development sides of the aircraft and atomic energy industries—that shows how high the quality of their work is. Yet on the staff of that firm there is not a single professional mechanical engineer. All the technical people who run the business and the works are ex-craftsmen who have had the ability and drive to build their own show and manage it.

I am whole-heartedly in favour of raising the academic standards of engineers, and of giving technicians every opportunity and encouragement to learn something of the science of engineering. But in the process I hope we don't erect unnecessary barriers between the professional engineer and the craftsman. Much of our industrial strength as a nation stems from the fact that we have had generations of skilled men. Unlike the new industrial nations, we don't have to plan everything so that it can be done by the unskilled and the semi-skilled. On the contrary, we must use to the full the unique abilities of our craftsmen. They, just as much as the professional engineer, are the descendants of George Stephenson.

CAPRICORN.

Weekly Survey

Not only Sputniks

The Russians have disconcertingly thrown out the calculations of the West on their ability to affect the rate of development in nuclear armaments and guided missiles. They may yet play an important part in affecting the trend of the trade cycle. There are indications that the American recession is losing its momentum and that in about six months' time United States industry may be recovering lost ground. When that happens, so the argument goes, there will be a useful recovery in the demand for world commodities and capital equipment. It may not be as easy as that.

The Russians are showing every indication of being willing to sell significant quantities of commodities and capital equipment on the world market. It is small consolation to the West that some of these supplies may be available owing to bad planning inside the Soviet bloc or that the recent rapid rate of technical change from conventional armaments to guided missiles may have reduced the demand for certain types of metal. The fact remains that the Russians have begun to unload on the world market increasing quantities of aluminium, tin, zinc, ferro-silicon and platinum. There have also been reports of offers of asbestos and copper. It may not be long before quantities of capital goods are also available from the same source.

If these Russian sales persist they may seriously delay the favourable impact of rising American industrial production on countries exporting primary products. If this be so, the rate of installation of new capacity for mines, refining and smelting plant may be delayed. Signs have not been lacking of delays in carrying out ambitious development projects owing to the North American recession. The Rhodesian copper mines and the Volta River hydro-electric and aluminium scheme are two outstanding examples of this.

Electric Power in Eastern Europe

In response to a request made by the Committee on Electric Power at its thirteenth session, the secretariat of the Economic Commission for Europe has prepared and published a report on possibilities of electric power exchanges between the countries of Central and South Eastern Europe. The extent of such exchanges is at present very limited, but the unequal distribution between the various countries of solid and liquid fuel reserves and hydro-electric resources, coupled with the rapid rise in demand for electricity throughout the area, suggests that over the next ten to fifteen years there will be scope for transfers of power on a considerable scale.

Total energy reserves of the countries in question, including hydro-electric potential and applying a 25 per cent conversion factor to reserves of hard and brown coal, petroleum and natural gas, measured in million kWh *per capita*, range from 11·1 in Poland, 4·8 in Yugoslavia, 3·9 in Turkey and 3·6 in Albania to only 1·2 in Eastern Germany, 0·9 in Greece and 0·5 in Hungary. Yet all these countries, together with Czechoslovakia, Rumania and Bulgaria, which occupy an intermediate position, show approximately the same annual average rate of increase in electricity consumption. For most countries in the group, this rate of increase has been equal to a doubling of consumption every five years, compared with doubling in ten years in most Western European countries.

The report concludes that before long Hungary and Eastern Germany will be compelled to import electric power from their neighbours, while Bulgaria and Czechoslovakia, though capable of meeting their own requirements, could only do so at a considerably higher cost than that at which they could import electricity.

The main difficulty in international transfers of electricity is shortage of capital in those countries which have surplus resources. Most of these countries, moreover, prefer to apply their available capital to internal development. International co-operation will therefore be required if the available resources are to be developed in the most economic way. The most immediate problems concern the joint development of the hydro-electric resources of the Danube, the rivers common to Bulgaria and Greece, Lakes Prespa and Okrid and the River Aliakmon, and the erection of thermal stations based on the brown coal of Poland.

France and the FTA

While the delay in forming a Government in France offers a continuing threat to negotiations on the Free Trade Area, support from industry and commerce continues to come in. Last month there was a joint statement put out by the industrial federations' and employers' organisations of Austria, Denmark, Norway, Sweden, Switzerland and the United Kingdom calling for the formation of a Free Trade Area (following on a conference held at Swedish instigation some weeks before).

Last week there was support of a similar kind forthcoming from the council of the International Chamber of Commerce at the end of a two-day session on the Free Trade Area in Paris. The interesting point in the meeting was a resolution presented by the president of the Swiss Watch Makers' Association calling for the establishment of a Free Trade Area and that the resolution received the support of representatives of the French Employers' Federation. The resolution pointed out that failure to negotiate a Free Trade Area might lead to a return to discrimination in trade in western Europe. It is a point gained if a French industrial organisation can be persuaded to see such a retrograde step developing if the Free Trade Area does not come into existence.

There is no mention in the resolution of the harmonisation of tariffs and quota elimination between the European Common Market and the Free Trade Area—this having always been regarded as a vital issue by those possible adherents to the FTA who are not already in the ECM. It is also noteworthy that according to the Swiss delegation in an interview after the conference the council had specifically rejected the idea of bilateral negotiations between the six Messina powers and each of the 11 other members of the proposed FTA. This idea has been favoured in France for some time, partly as a question of principle and partly also perhaps for the more cynical reason that tariff reduction would take longer to bring about in the Free Trade Area if it were the subject of bilateral negotiation among members. All this does not add up to acceptance of the idea of the FTA in France, but it suggests that the possibility of a negotiated compromise between the United Kingdom and French points of view is slightly increasing.

Lagging Plans in India

India's second five-year plan is running behind schedule. The total estimated outlay has been put at £3,600 million and actual outlay can only be £3,200 million. This will involve a drop in potential employment arising out of the plan from 7,900,000 jobs to 6,500,000. It is less than the increase in the labour force over the same period.

These estimates are contained in a memorandum put out by the Planning Commission on the

progress and prospects of India's second five-year development plan. The commission says that the lower figure can still be met if taxes are increased and non-development expenditure cut. The £3,200 million is therefore exceedingly problematical and is indeed no more than a revised target. A good deal of the money spent so far has been found by deficit financing; more has been raised this way (although the plan is only entering its third year) than was expected to accrue from deficit financing over the whole life of the plan.

To date, the industrial side of the plan has done fairly well and between 70 and 75 per cent of the originally estimated five-year figure will be attained. The main miscalculation has been in foodstuffs: drought has caused shortages and the peasants have been slow to take advantage of irrigation facilities because they have been reluctant to pay the charges. As well as a certain amount of financial optimism there has thus been (as has so often happened before) a serious under-estimate of the delaying power of conservatism on the land in carrying through technical changes.

Future of the New Towns

Two points of substance have been brought to the attention of the Government by the Town and Country Planning Association. The first of these concerns the later stages in the development of new towns and the second the ultimate form of control which the Government should exercise over their administration.

The Association argues that new town development corporations should be kept in existence during the second stage of the existence of new towns. The second stage is reached when public amenities, shops and jobs have to be found for the growing population. The rate of increase in the population of these towns is likely to be above average, even when the first intake of immigrants has ceased, owing to the large number of young families. The Association thinks indeed that organised immigration should stop once a town has reached about 75 per cent of its planned long-term population level. Catering for this last 25 per cent is, of course, a difficult problem. It represents the population bulge to some extent, except in the very newest of the post-war satellite towns. In consequence, it is not easy to plan a long-term programme of economic and social investment in these towns without wasting resources. There is therefore much to be said for the Association's plea that development corporations, which have had considerable experience in town planning over the last decade, should continue in existence during stage two of the towns' growth.

The Association is somewhat sceptical about the Government's decision to set up a central agency to own the new towns. It is anxious that these new social groups should establish their entity by the development of local management. It does not see any advantage in central supervision unless this incidentally relaxes Treasury control. It thinks that the eventual form of administration of the new towns should be worked out gradually. It would have the corporations of the new towns include a minority of local residents, not necessarily all elected councillors, from nominees suggested by the local authority. The aim should certainly be to obtain the advantages from local control which properly harnessed local patriotism might give and to graft this on to some form of efficient management on commercial lines.

Agricultural Engineering

Although Britain could take a certain amount of pride in being the world's leading country in the export of agricultural machinery—the industry took seventh place in the country's export business—there was little room for complacency if we were to remain in the lead in the face of increasing competition from abroad. Mr. Lionel Harper, President of the Agricultural Engineers' Association, gave this warning at the luncheon which followed the annual general meeting, held in London earlier this month. He emphasised the need for more research, leading to more reliable mechanism and the elimination of grease guns, belts, chains and spanners. He also made a plea for more standardisation, not only as regards ranges and sizes of machines and equipment, but of components, since this would reduce costs and benefit farmers.

The training of a sufficient number of agricultural engineers was of vital importance to the industry. Mr. Harper referred to the establishment of a National College of Agricultural Engineering, provision for which was made by the Chancellor of the Exchequer, Mr. Heathcoat Amory, in his Budget last month. The appointment of a chairman of the board of governors was under consideration by Mr. Geoffrey Lloyd, Minister of Education, and an announcement was expected shortly. A site near Bedford had been selected for the building, which would take two years to complete. The college will provide for 35 to 50 students a year, and it is intended to take a high proportion from overseas, thus spreading a knowledge of British achievements and techniques in agricultural machinery which, indirectly, should promote future sales.

The President of the Institution of British Agricultural Engineers, Mr. John M. Chambers, also emphasised the importance of reasonable spending on research and development in relation to the industry's income if we were to retain our lead as premier exporter of farming machinery. Education must play its part, and the Institution's National Diploma in Agricultural Engineering was serving a useful purpose. It was the intention of the Institution to make more widely known to schoolboys the opportunities offered by agricultural engineering.

High Vacuum in Europe

The progress of high vacuum techniques in industry has recently been marked by two important groupings of established manufacturers of high-vacuum equipment. The highly successful Edwards High Vacuum Limited announced the official opening on 10 April in Milan of new factory premises to be operated by a new company, Edwards Alto Vuoto A.p.A., jointly owned by Edwards and Societa Apparecchi Elettrici and Scientifici S.p.A. The object of the company is to market high-vacuum equipment produced in England, adapting it to the requirements of the Italian market, thus—as the company put it—"linking the highly skilled craftsmanship of Italy with the scientific research and precision production of the British factory."

The other major development is the cross-licensing agreement made by the National Research Corporation of Cambridge, Massachusetts, and the Leybold-Hochvakuum-Anlagen, G.m.b.H., of Cologne. The agreement was made on behalf of N.R.C. Equipment Corporation, a wholly-owned subsidiary of N.R.C., which is the largest completely integrated source of high and ultra-high vacuum equipment and technology in the United States. The agreement is for five years and covers four specific areas of applied high-vacuum engineering, with applications in the electric power and electronic industries and in the plastics industry (for thermal setting or heat hardening processes).

There is little doubt that the Germans have a great deal to contribute in this field, particularly in the vacuum processing of organic liquids used in high-voltage applications. The United States-German alliance will doubtless provide tough competition for Edwards High Vacuum but they too are in a good technical position. The battle, if there is to be one, may be won in the field of finance rather than in the laboratory.

Letters to the Editor

RAILWAY RENAISSANCE

SIR, With reference to your comment in your article "Railway Renaissance" (2 May, p. 545) that "the railways have reacted to their financial difficulties by a cheese-paring policy," may I point out that the Commission are required by statute to pay their way as a commercial undertaking, "taking one year with another." It is for this reason that they seek to get rid of wholly uneconomic services, even though they are not always able to do so.

I would also point out that while it is true that the Commission have the virtual monopoly of *railway* transport, this is not really a monopoly to-day in view of the very extensive competition to which the railways are subjected by over 1,200,000 road haulage vehicles. The Commission's efforts to make the railways pay thus involve a purposeful concentration upon those traffics and services for which railways are best fitted.

Yours faithfully,
J. H. BREBNER,
Public Relations Adviser.

British Transport Commission,
222 Marylebone Road,
London, N.W.1.
7 May, 1958.

Editor's Note: A letter on this subject from Brigadier T. I. Lloyd, Railway Conversion League, appeared on p. 580 of our issue of 9 May.

TRAINING OF ENGINEERS

SIR, I have read Mr. H. Masheder's letter, published on p. 547 of ENGINEERING of 2 May, and the conclusion seems to be that the engineer must, in no way, consider himself inferior to a Ph.D.

Mr. Masheder, in his letter, seems to take an entirely negative point of view. The positive view is that the university, the physicist and the engineer ultimately work to the same end. The university trains the engineer and the physicist; the physicist deals with the fundamental problems and the engineer puts them into practice, and I see no difference of view in the three cases. They are all creative, one of thought, the second of fundamentals and the third of practice, and the question of degree does not arise.

Yours faithfully,
A. H. MCQUEEN.

15 Great George Street,
Bristol, 1.
9 May, 1958.

12 in = 1 ft

SIR, Your "Plain Words" about model engineering this week remind me of the time when I took an enthusiastic toolmaker to the Model Engineer Exhibition. Discussing the fascination of this hobby, I suggested that the development of our own automatic capstan lathes really came into the same category. Without hesitation he said: "That's right. Model making on a scale of twelve inches to the foot."

Yours sincerely,
IAN NICKOLS.

Nickols Automatics Limited,
Oxted Mill,
Oxted, Surrey.
9 May, 1958.

ANODE AND POSITIVE

SIR, I was glad to see Mr. Michael Milford's letter in your issue of 2 May, contributing to the discussion on this subject. It had not occurred to me at the time I wrote my previous letter to refer to the *Admiralty Handbook of Wireless Telegraphy* (1938), although I have a copy.

Since writing that letter I have delved into more books, and perhaps, Sir, you will spare me further space unless you consider I am flogging

a dead horse. It seems surprising that there appeared to be no doubt in the minds of the early electricians and I quote from Culley's *Practical Telegraphy* (1867). In describing the simple voltaic cell he says:—

" The electricity is supposed to set out from the more oxidable metal, called the ' positive ' or generating plate, because it furnishes the supply of electricity—passes through the fluid to the less oxidable metal, called the ' negative ' or ' collecting ' plate because it collects the electricity from the liquid, and thence by the connecting wire to the zinc again. But the end of a battery, called the generating plate (generally zinc) is called the ' negative ' pole because it is there that the negative electricity is accumulated (the positive having passed into the liquid); while for a similar reason the last ' collecting plate ' is called the ' positive pole,' since by it the positive electricity leaves the battery. When zinc and copper are formed into a battery, the positive electricity passes from the zinc through the liquid to the copper, and from the copper to the conducting wire attached to it."

The curious phaseology is no doubt due to the two-fluid theory of electricity in vogue at that time.

In Ternant's *Les Télégraphes* (1881), under the description of the Leclanché cell, it is pointed out that the carbon forms the negative electrode, so apparently the French agreed with us at that time. In both Everett's *Text Book of Physics* (1883), and Sir Oliver Lodge's *Modern Views of Electricity* (1907), reference is made to Sir William Thomson's (Lord Kelvin) experiments demonstrating that when zinc and copper plates are in contact, the zinc is positively charged and the copper negatively. This was originally shown by Volta using a condensing electroscope. Turning now to J. A. Fleming's (afterwards Sir Ambrose) *Magnets and Electric Currents* (1902), it is surprising to find that he uses the terms pole and electrode indiscriminately. On the subject of primary batteries he says:—

" In nearly all the widely used primary batteries the negative electrode is a plate or rod of amalgamated zinc. This is associated with a plate or rod of some substance not capable of being oxidised at a low temperature, and which is at the same time a good conductor. The materials most usually employed for the positive electrode are copper, silver, platinum, carbon, carbon in association with pyrolusite or peroxide of manganese, or else compressed peroxide of lead. If a plate of zinc and one of any of the above bodies (which are electrochemically very different from zinc) are placed together in a vessel in dilute acid or alkali, we then have in this voltaic couple a source of electro-motive force. If the plates are metallically connected by a wire outside the cell, a current is produced in the wire which flows in the wire from the positive electrode or pole to the negative pole, and back through the electrolyte of the cell."

Chemical equations are given, showing the action taking place in both the simple voltaic cell and the Daniell cell and, in each case, the zinc is referred to as the negative plate and the copper as the positive plate. It is difficult to understand Fleming's departure from the recognised terminology as he was usually so precise in most of his books. The explanation may be that the book is a reprint of a series of lectures originally given to artisans and that he did not want to confuse them with what may be considered an academic point of view.

In the *Dictionary of Applied Physics*, vol. 2 (1922), edited by Sir Richard Glazebrook, under the explanation of the simple voltaic cell, it is stated that when two metals, such as zinc and copper, are placed in contact, the zinc is found by electro-static tests to be at the higher potential. It goes on to state that the terminals in the plates are called the poles, and the current on the exterior circuit is found to flow from the electro-negative plate. Consequently, the terminal on the electro negative plate (e.g. carbon) is the positive pole and the terminal on the electro-positive plate (e.g. zinc) is the negative pole.

I should like to refer to two more books: Duncan and Starling's *Magnetism and Electricity* (1922), and G. R. Noakes's *New Intermediate Physics* (1957). In the former, under the simple voltaic cell, it states: " Remembering that hydrogen appears at the kathode and SO_4 at the anode, we see that the current leaves the cell at the copper electrode. The copper is called the *positive pole* of the cell and the zinc the *negative pole*." Further on, under the description of the Daniell cell, it gives the chemical equations and says that while the anode zinc is dissolved, at the same time copper is deposited on the cathode.

In *New Intermediate Physics*, after giving the terms used in electrolysis as defined by Faraday, it states, in the case of the Daniell cell, " the conventional current flows from zinc to copper through the liquids, so that zinc is the anode and copper the cathode." Again, under a paragraph headed " Self depolarisation, the Daniell cell," it states that the anode is a rod of pure zinc and the cathode is a copper plate, and a diagram is given marking the leads from the copper and zinc terminals as positive and negative respectively. Also under the Leclanché cell it states that there is a zinc anode and carbon cathode.

While writing the above it occurred to me that a paper appeared in the *Journal of the Institution of Electrical Engineers* in 1911, in my early days as a student, on " The Benkö Primary Battery and its Applications," by W. R. Cooper, and I have turned it up (vol. 46, p. 741) as a matter of interest and quote from it: " The cell is due to the Hungarian engineer Stephan Benkö, and depends essentially on the idea that if the layer of electrolyte on the positive plate (that is, the electro-negative element) is removed as fast as polarisation sets in, the EMF will be maintained constant." So here we have the carbon plate referred to as the positive plate or the electro-negative element.

Well, to the young student it must appear all very confusing, and I think authors of text-books should make a serious attempt at uniformity of the various terms employed in this connection. Whether these terms have been standardised by the British Standards Institution, I do not know. I suggest that the Science Masters' Association and the Education Discussion Circle of the Institution of Electrical Engineers could very usefully hold a conference on this and other controversial electrical matters.

Yours faithfully,

J. F. PERRIN.

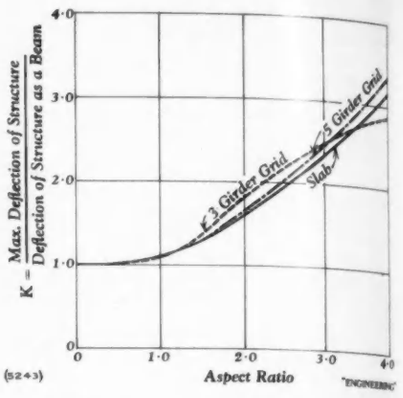
6 Cavendish Avenue,
Welling,
Kent.
8 May, 1958.

Editor's Note: This correspondence began with a letter " Anode and Positive are Not Synonymous " from Mr. G. H. C. Nicholls in our issue of 4 April, p. 419. Mr. Perrin's previous letter appeared on 18 April, p. 484, and the letter from Mr. Milford on 2 May, p. 547.

STIFFENING EFFECTS OF BRIDGE BEAMS

SIR, In his paper " Stiffening Effects of Edge Beams on a Right Slab Bridge " (ENGRG., 25 April, '58, p. 539), Mr. J. A. N. Lee makes it appear that the analysis of a slab by an equivalent grid is either inaccurate or, by reason of the complexity of the calculations, impracticable. This view is rather misleading and the problem has, in fact, been discussed in some detail by Dr. L. G. Jaeger and myself in a paper to the American Society of Civil Engineers (Structural Division, Proceedings Paper No. 1023, July, 1956). In this paper the representation of a slab by a grid is demonstrated and a very simple method of analysis, based on plotted distribution coefficients, is described. Very good agreement has been found between bending moments and deflections calculated by this method and experimental values from tests on concrete structures.

In making his comparison, Mr. Lee has chosen to consider a torsionless structure—presumably to simplify his grid calculations. If the same comparison is carried out between a real slab, that is, one possessing torsional rigidity, and the corresponding equivalent grid, a much more favourable result will be obtained, as shown in the accompanying diagram. It is important to realise, however, that the value of K for a grid will tend towards a value equal to the number of longitudinals. Thus, the curve given



by a three-girder grid flattens off at $K = 3{\cdot}0$ because, with a corresponding plate aspect ratio of 4·0 or more, practically all the load is taken by the centre longitudinal. As might be expected, a better representation is given by increasing the number of longitudinals to five. For aspect ratios up to about 6·0 there will be little advantage in increasing the number of longitudinals in the equivalent grid, at least as regards calculation of the central deflection of the structure. It has, in fact, been found that the transverse deflected forms of corresponding grids having more than about five longitudinals are the same.

Similar considerations apply to the torsionless case examined by Mr. Lee, but as the ratio of maximum to mean deflection of the structure at a given aspect ratio is here considerably greater, it follows that the minimum number of girders which may be taken in the equivalent grid will increase more rapidly than in the torsionally stiff case. The hypothetical torsionless slab might be applied to a deck consisting of a concrete slab resting on steel I-beams and, in this connection, Mr. Lee's curves give a useful indication of the limitations of this analogy when applied to systems having only a few longitudinal members.

It might be added in conclusion that the slab with edge stiffening beams can also be satisfactorily dealt with by grid framework analysis.

Yours faithfully,

A. W. HENDRY,
Professor of Building Science.

The University,
Liverpool.
6 May, 1958

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INSTITUTE OF FUEL

Evidence of the growing importance of the Institute of Fuel at home and overseas is evidenced by the recent formation of a Group of the Institute in Newcastle, New South Wales, and the arrangements, now under way, for the setting up of a new Group in the Argentine and a South-Eastern Section in this country. In the course of a speech made in welcoming the guests at the annual luncheon of the Institute in London on 24 April, the President, Mr. H. McNeil, paid tribute to the work done by the late Dr. G. E. Foxwell in fostering education in fuel technology and added that it was appropriate that the newly-created Foxwell Memorial Award should be devoted mainly to educational purposes. An exhibition, scholarship or fellowship would be endowed.

During the luncheon, the first Bone-Wheeler Medal, and prize of £50, commemorating the names of Professor W. A. Bone of Imperial College, London, and Professor R. V. Wheeler of the University of Sheffield, was presented to Mr. A. M. Freedman, of the British Coal Utilisation Research Association for his paper, " Experience with the Humidification of Combustion Air to Prevent Boiler Fouling."

Plant and Equipment

Earth Moving and Bulk-Handling MECHANICAL HANDLING *Conveyors, Cranes and Hoists*

Concluded from page 583

CONTINUING our description of some exhibits at the Mechanical Handling Exhibition at Earls Court—which closes to-morrow, 17 May—another new power shovel with Brockhouse torque converter transmission is shown by the Merton Engineering Company Limited, Feltham, Middlesex. A front-wheel drive two-way loader (Fig. 7), it can discharge either to the front or the rear. The bucket capacity is 1 cu. yd, and the loader is powered by a 61·5 h.p. Ford Major diesel engine. The drive is through an epicyclic gearbox with power shift, giving two forward and one reverse speeds.

A new hydraulic power grab for the Dinkum Digger Major trench excavator has been introduced by Whitlock Brothers Limited, Great Yeldham, Essex, and was shown on their stand. It is claimed to be the first all-hydraulic tractor-mounted power grab in this country. The Whitlock power grab, of $\frac{3}{8}$ cu. yd capacity, has a wide range of uses. Not only will it load and unload such materials as coal, coke, sand, gravel, aggregates, etc., over the side of a truck or hopper exceeding 10 ft in height and on to scaffolding, but it will also dig square-sided holes suitable for telegraph and electric light poles, concrete piers, etc., to a depth of 9 ft. It will also carry out mass excavation to a depth of 16 ft and can be used for ditch cleaning and other clearance work.

Fig. 7 Front-wheel drive two-way loader. Merton Engineering Co. Ltd.

In comparison with cable-operated grabs, the hydraulically-opened grab jaws have the advantage that, when digging in difficult materials, tremendous down-pressure can be exerted on the jaws while they are being closed. The Whitlock power grab has a high rate of slewing through an arc of 190° and can be attached to any standard Dinkum Digger Major in a matter of minutes.

A new slewing ring for excavators is shown by Priestman Brothers Limited, Brentford, Middlesex. Known as the cross-roll bearing, and designed in collaboration with British Timken Limited, it is claimed to provide perfect distribution of the load, and thereby makes it possible to lift greater loads, since hitherto it has been the strength of the slewing ring that has limited load lifting capacity. The unit is supplied grease-packed for life, and adequately sealed—hence maintenance should be unnecessary between major overhauls, which themselves are unlikely to be called for except at rare intervals. As shown in Fig. 9, the cross-roll bearing consists of four separately-machined components (1, 2, 3, 4) forming a diamond-pattern race section. These are bolted together as two rings, with the outer member carrying the slewing gear (*p*), and being immovably bolted to the crawler frame. The inner member is set-screwed by high-tensile steel screws to the bottom of the revolving superstructure. The specially-made Timken rollers (*a*, *b*), alternately spaced on the pitch circle of the races by means of a pressed steel cage, contact the opposing rolling surfaces of the outer and inner rings; the crossing of their axes, in combination with the inclination of the roller paths, enables the bearing to sustain radial loads and axial loads in both directions. Spigoting of the revolving superstructure and crawler frame (an essential but undesirable feature of the hook roller design) is therefore unnecessary.

Fig. 8 Hydraulic power grab. Whitlock Bros. Ltd.

The cross-roll bearing is already fitted on Priestman's own Tiger Five-X and Cub V excavators.

The Monoveyor (Fig. 10), shown by Road Machines (Drayton) Limited, West Drayton, Middlesex, consists of a driverless prime-mover and two powered trailers. It will tow a further unpowered trailer on gradients up to 1 in 12, loaded to capacity. Each trailer, powered or unpowered, has a load capacity of 1,800 lb; trailer bodies can be developed to suit requirements. The prime-mover has a diesel engine, either air-cooled, or for underground work water-cooled, flame-proofed and exhaust quenched. Transmission is hydraulic, three engine-driven pumps supplying six motors, two on the prime-mover and two on each powered trailer, so that there are six driving wheels. Complete stability is achieved by the stabilising wheels on each unit. They are independently adjustable and make contact on the channel at the bottom of the rail. It is virtually impossible to derail the equipment. Dead-man type hydraulic brakes are incorporated on each motor, ensuring safety and control when negotiating a down gradient. Automatic stopping is provided. Easily-laid standard box-section rail is employed. Under average conditions, 100 yards can be laid by two men in 30 minutes.

The introduction of very dry, harsh concrete has presented a new handling problem to the building and civil engineering industry. Such concrete will not flow naturally and cannot be "placed" by ordinary hand methods. Equipment developed to overcome this problem was shown on the stand of C. H. Johnson (Machinery) Limited, Stockport. The Johnson Multibrator is a very-high-frequency immersion-poker vibrator incorporating a brushless squirrel-cage motor within the poker itself. Low-voltage/high-frequency current is fed to the motor through trailing cables of up to 300 ft long from either a frequency converter or from a diesel-driven

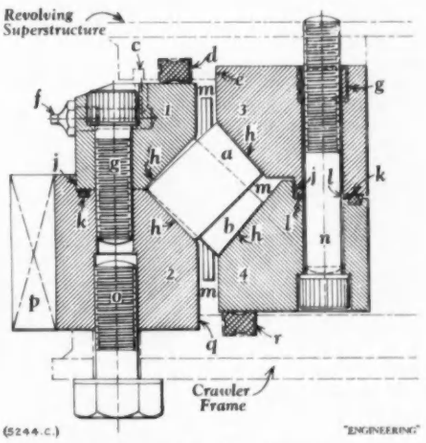


Fig. 9 Part cross-section through cross-roll bearing for excavator slewing motion. Priestman Bros. Ltd.

a and *b*. Taper rollers in Krupps steel, hardened and ground.
c. Grease-filled labyrinth prevents ingress of water or dirt.
d. Cruciform seal of synthetic rubber—defence against dirt and dust.
e. Bearing locating spigot (upper).
f. Grease feed to labyrinth.
g. Ring holding screw, securing upper and lower members—peened over to prevent slacking back.
h. Hardened bearing face (500/550 BHN).
j. Ring locating spigot.
k. "O" ring seal prevents entry of moisture.
l. Pre-load shims adjusted to eliminate all play in bearing.
m. Packed-for-life with extreme-pressure lubricant.
n. Bearing holding screws (inner) securing inner section of bearing to revolving superstructure.
o. Bearing holding screws (outer) securing outer section to crawler frame.
p. Spur gear.
q. Bearing locating spigot (lower).
r. Cruciform sealing ring of synthetic rubber guards against loss of grease from bearing, and against entry of foreign matter.
1, 2, 3, 4. Steel ring forgings fully hardened, and machined to precision limits.

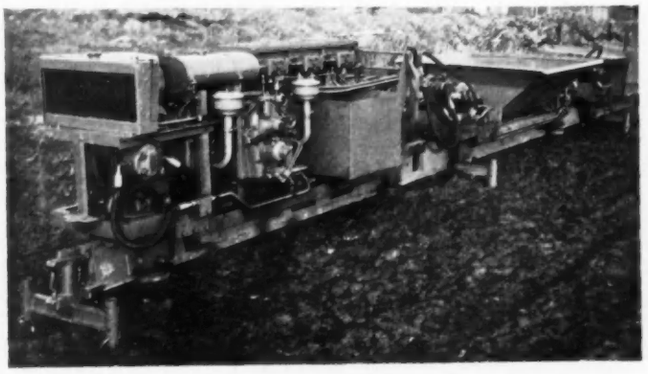


Fig. 10 The Monoveyor transporter. Road Machines (Drayton) Ltd.

Continuing Plant and Equipment

alternator. Thus, it is now possible to leave the prime-mover on the ground while concrete can be placed by vibration on the tenth floor. The cables carry only 125 volts which is generally approved by all authorities and considered entirely safe. The unit exhibited and shown in Fig. 11 is the Johnson frequency converter which would be employed on those sites where 400/440 volt current is available. When no power supply is available, the diesel-driven alternator provides the low-voltage current to feed the pokers. Both these units will drive four pokers simultaneously without power drop.

In conveying equipment, the trends are towards automation and greater versatility. A fully automatic sub-circuit conveyor connected in parallel to the main circuit is displayed by A. and C. Jenner Limited, Mitcham, Surrey, who have devoted considerable attention to the automatic removal or replacement of a pre-selected number of items to or from a continuous line from a completely remote control station.

The main circuit conveyor may be carrying almost any type of goods, or be a part of any continuous process line. When, say, an operator needs to do work on these goods, he " tele-dials " the quantity he requires (on a telephone type dial) and they are automatically diverted from the main conveyor to his station. As he completes his operations, he dials them back to the main conveyor, again in any numbers.

The tele-controls for diversion of items from the main conveyor and for their re-dispatch to it are separate and independent. They can be sited together, near to the operator for his use, or can be apart from each other and at a distance for operation from a main control desk.

The exhibit demonstrates this diversion of goods from the main circuit by means of a three-stage automatic lift with one right-angled exit. Their return to the main circuit is by an automatic skate-wheel junction. The lift is not essential to the system as just described, but demonstrates that the system is equally applicable to multi-floor layouts.

An automatic routing conveyor system is also demonstrated by Thos. W. Ward Limited, Sheffield. The system is of the belt and conveyor type, handling packages of various weights and sizes. A digital control process is used, based on a control panel having the necessary instructions fed into it, so that the various transfers along the line are operated automatically from the panel's " memorised " route. In spite of the intricacy of the system, the routing is capable of infinite variation, depending on the programme fed into the control apparatus. It can also incorporate order selection along with routing, or be adapted solely to order selection.

Fully automatic mechanical handling by the overhead monorail system—including tipping, on-line weighing, dipping and raising or lowering loads to different levels—is demonstrated by British MonoRail Limited, Brighouse, Yorks. There are three main working exhibits. In one exhibit a completely automatic selective dispatch system carries two 360° tipping buckets from a filling station to one of two tipping points. By using a combination of power-operated switches, power-driven MonoTractors and automatic lift sections, a whole series of pre-selected operations can be carried out by simply pushing a button. The conductors used throughout the installation have been fitted with the new Kant-Shock extruded p.v.c. shielding, shown for the first time. The shielding is claimed to prevent the possibility of shocks through accidental physical contact with the live conductor.

The system is laid out as a continuous loop on two levels, incorporating a lifting section and a dipping section at opposite ends. A second track, running parallel to half of the loop, is joined to the continuous main track by two two-way motorised switches. After the empty bucket, pulled by a MonoTractor, leaves the dispatch station it passes to a lower level, via the dipping section, and trips the required switches in passing so that the loaded bucket and tractor are set in motion on the high level circuit. At the tipping section, the full bucket automatically discharges its load into the low level bucket and both of them return to the dispatch station for the next cycle of operation.

The other two MonoRail exhibits can be interlocked and show how a semi-automatic power and/or manual bridge crane system can be used in conjunction with an adjoining manual-electric monorail installation incorporating a power-operated dipping-section, an on-line weigher, two-way and three-way switches and a crossover.

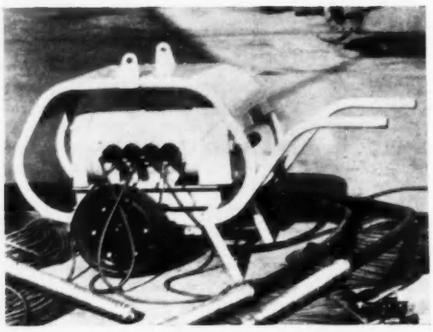


Fig. 11 Frequency converter for concrete vibrator. C. H. Johnson (Machinery) Ltd.

Fig. 12 Rapistan spur curve. Manufacturers Equipment Co. Ltd.

Another demonstration of the application of electronics to conveyor control is on view on the stand of Manufacturers Equipment Company Limited, Hull. Electronic equipment developed by E.M.I. Electronics Limited, Hayes, Middlesex, is used to release packages from Rapistan flow racks on to the conveying system. On release from the racks, the packages pass through a swing tray elevator which operates so as to combine three lanes of packages on to one belt. An automatic spacing device ensures that the packages are spaced regularly at 5 sec intervals. The packages then pass on to an electronic weighing machine—a digitally coded disc converts the movement of the scale pointer into positional information which can be used readily for remote display, automatic print-out by teleprinter or electric typewriter, or for control purposes. In the present exhibit, the weighing machine has an indicator board adjacent to it on which are recorded the weights of each package to the nearest ½ oz, and also the total number of packages passing through the system. After weighing, the packages pass on to a coded router selector. Fixed to each package is a black-and-white coded label, so positioned that it is scanned by the selector heads, which are situated just before each Rapistan spur curve (Fig. 12), or ploughing-off point. The selector heads are identical and consist of a number of transistor photocells and light sources; however, the photocells are so connected that each selector responds only to one particular code arrangement. Thus packages destined for ploughing-off at a particular selection point are labelled accordingly, and selection will take place only at that point.

A new high-capacity high-speed conveyor belt for handling bulk material at steep angles without the need for cleats or flare-plates is shown on the stand of C. H. Johnson (Machinery) Limited, Stockport. Their Corruband flanged conveyor belting (Fig. 13) can be seen handling ¾ in round natural gravel at 27° inclination. The belt is 24 in wide, and runs at 200 ft per min with a capacity of 190 tons per hour. Corruband belting incorporates flanges 3 in deep, and is designed so that belts up to four-ply can be employed on drums as small as 7½ in diameter.

Fig. 13 Corruband flanged conveyor belting. C. H. Johnson (Machinery) Ltd.

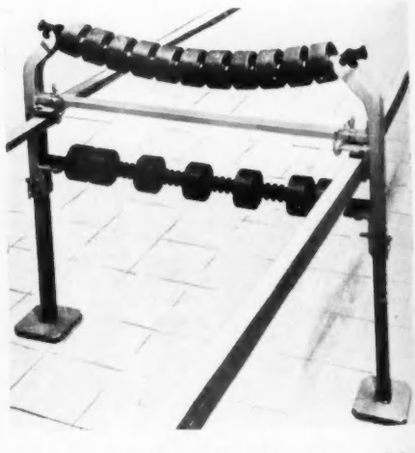


Fig. 14 Flexiroll troughing idler system. Fisher and Ludlow Ltd.

It is carried on flat idlers spaced at 4 ft for materials up to 50 lb per cu. ft, and 3 ft 6 in for materials up to 130 lb per cu. ft. Where troughed idlers already exist, Corruband belting can be successfully employed with greatly increased capacity.

This demonstration conveyor is powered by Johnson-Bauer drum motors, in which the driving motor is incorporated in the drum, thus simplifying and reducing the cost of the conveyor structure. Johnson-Bauer drum motors are available in sizes from 6 in diameter, ¼ b.h.p. to 20 in diameter, 15 h.p. Those on view at the exhibition are 8 in diameter, 1 b.h.p., and provide a belt speed of 200 ft per min.

Fig. 15 Scalper for removing oversize material. C. J. R. Fyson and Son.

The Flexiroll troughing idler system (Fig. 14), shown by Fisher and Ludlow Limited, Birmingham, is another contribution to the problem of conveying coal, ore and other granular materials. Flexiroll shapes itself to the load, and cushions and guards the belt. The supporting rollers are of moulded plastics and canvas and are carried on nylon bearings which require no lubrication. Fire risks are eliminated, since there is no metal-to-metal contact, and the system is corrosion and abrasion resistant.

A new scalper (Fig. 15) for use in conjunction with a feed conveyor handling bulk material is shown by C. J. R. Fyson and Son, Soham, Cambridge. The feed conveyor is used to load a stock-piling conveyor direct from a lorry. The purpose of the scalper is to remove from the belt all lumps above a predetermined size. Two such scalpers in series are shown on the exhibit conveyor, so that two consecutive sizes of lumps are removed and only the " throughs " delivered on to the stock-piling conveyor.

A flexible fold-belt conveyor, known as the Serpentix, made under licence from Albert Stübbe (Germany), is shown by Mitchell Engineering Limited, 1 Bedford Square, London, W.C.1. The Serpentix can climb at 35° and turn simultaneously in a tight curve. It is made up of sections bolted together, each section being of moulded rubber bonded to steel stiffening plates, the belt being folded between the plates. The rubber belt itself is completely free from tension and friction: all the pull is taken by a chain connected to the steel plates under the belt. The chain rides on roller carriages incorporating permanently lubricated bearings.

A model of the first chair lift to be installed in Great Britain is shown by British Ropeway Engineering Limited, Plantation House, Mincing Lane, London, E.C.3—the Dudley Zoo chairlift which was due to be opened last Sunday at Dudley, Worcester. This little installation, 90 yards long and operating over a difference in level of just over 100 ft, is designed to give visitors to the zoo the unusual experience of being suspended over a den of wild animals; it can carry 1,000 passengers an hour.

The latest developments in conveyor belting and similar items on view at Earl's Court include a fire-resistant anti-load-slip belt capable of carrying coal up or down gradients steeper than 1 in 3, shown by BTR Industries Limited, London; Rilflex Terylene-based multiply anti-static fire-resistant conveyor belting, shown by Rubber Improvements Limited, Wellingborough, and Armadillo chute lining, a tough rubber sheet with high abrasion resistance, by the Goodyear Tyre and Rubber Company (Great Britain), Limited, Wolverhampton.

Fig. 16 Fast standard mobile crane. Ransomes and Rapier Ltd.

Fig. 17 10 cwt Aro-Broomwade hoist. Broom and Wade Ltd.

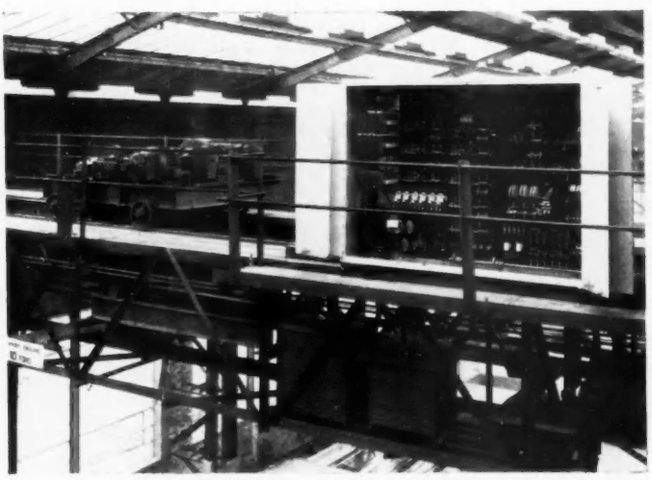


Fig. 18 Twin hoist control. Metropolitan-Vickers Electrical Co. Ltd.

Dominating the ground floor of Earl's Court are the exhibits of two crane makers—Steels Engineering Products Limited, Sunderland; and the George Cohen 600 Group Limited, Wood Lane, London, W.12. The latter company showed their Jones KL10-10 Fast Travel 26 ton crane, which has a 90 ft jib and 15 ft mast, at the Leipzig fair earlier this year. A lorry-mounted crane, it employs a single diesel engine for travelling at speeds up to 30 m.p.h. and also to power all crane motions. Examples of the new range of Coles diesel-electric mobile cranes shown by Steels Engineering Products Limited include a lorry-mounted crane with a maximum lift capacity of 25 tons at 10 ft radius, available with jibs up to 120 ft in length. Other members of the family come in capacities from 5 to 50 tons, in road and rail versions.

A new fast mobile crane was also on view on the stand of Ransomes and Rapier Limited, Ipswich. The Rapier 4 fast standard mobile crane is designed to meet the road travelling requirements of inter-depot service on railways, road haulage systems and individual undertakings, and can work in congested areas inaccessible to a lorry-mounted crane. With the diesel drive, it can travel at the speed of normal road traffic. It is claimed to be exceptionally manoeuvrable and light in handling.

The Rapier 4 fast standard mobile crane has a lifting capacity of 8,000 lb at 4 ft outreach giving a height of lift of 14 ft; or 3,600 lb at 10 ft 4 in outreach, lifting to a height of 6 ft. Short and long jib extensions are available giving higher lifts and greater outreaches at reduced loads. The total weight of the machine is 6·94 tons.

The Aro-Broomwade pneumatic hoist (Fig. 17) shown by Broom and Wade Limited, High Wycombe, is claimed to be the smallest and lightest of its kind for the specified capacity, 10 cwt, and speed of lift, 25 ft per min. It measures 10½ in by 5 in and weighs only 29 lb with Pull-cable control, or 34 lb with pendant control. The vane-type motor is fitted with a silencer, and all rotating and oscillating parts are carried on ball or needle bearing mountings. An automatic brake locks when power is shut off, and the load is held up in any air-supply failure, but can be lowered safely and speedily by the throttle control.

A twin-motor hoist control system (Fig. 18) on a 7½ ton overhead travelling crane is shown by Metropolitan-Vickers Electrical Company Limited, Manchester. The system of a.c. hoist control demonstrated employs two identical induction motors, each of approximately 65 per cent of the horse-power required, and both permanently geared to the hoist motion and running at the same speed. Two motors are used in conjunction to give: hoisting and lowering creep speeds varying little with load; slow light hook speeds; electric braking when lowering; a lively hook on lowering notches, i.e., adequate drive-down torques so that the hook and load are made to reach a steady speed quickly (in contrast to d.c. potentiometer lowering). The latest type of driver's control position takes the form of two control pedestals and a separate chair to permit driving from either a seated or standing position. This is found to be of advantage when spotting awkwardly situated loads. It can, however, only be used with contactor-controlled equipment.

Short-stroke minimum-effort controllers are used with three notches only in either direction, giving slow speed on two notches followed by automatic acceleration to full speed on the third notch. The hydraulic foot brake equipment for the long-travel motion is mounted under the cab with an accessible inspection cover in the cab floor. The operating pedal is located between the control pedestals to be easily accessible to a standing or seated driver.

The cabin is normally panelled with armour plate glass and sliding windows on three sides to give unobstructed vision.

The Human Element

Wealth, Investment and the Unions

Last week the market in gilt-edged securities on the London Stock Exchange wilted for a day or so. There was more to this than a decline in confidence because there was a bus strike and a prospect of one on the railways. Such a decline there was, but other factors were at work. The unions themselves were selling gilt-edged securities. There were reports that the Transport and General Workers Union was going into cash because it had a strike on its hands. There is a grim humour in the thought that if ever there were another general strike, the country's credit might be more disturbed by heavy sales of securities by the trade union movement than by a fall in public confidence in the national economy.

It is thought that the unions hold among them something of the order of £20 million and £30 million Government stock and have other substantial holdings as well. It is not long since the National Union of Mineworkers was congratulating itself that its funds were tucked away in a wide range of securities and that it held significant quantities of industrial shares. Those Socialists who hold the City of London and its kindred organisations in such little esteem and would dearly like to tamper with the market in negotiable securities might be surprised at the hornets' nest they could stir up. Wealthy unions with large reserves and pensions funds skilfully invested in Stock Exchange securities might suddenly champion the City's capital institutions. The unions might make short work of Socialist theory about control of the capital market. Wealth, like misery, acquaints a man with strange bed-fellows.

Labour Pattern

At the middle of April there were 444,000 unemployed, an increase of 11,000 on the month. This means that unemployed stayed at 2 per cent of the total in employment. There was an increase in those wholly unemployed of 12,000, but those temporarily "free" fell by 1,000. The bad pockets of unemployed are still there, as for example in the North of Ireland where the percentage has risen to 10·8 per cent.

The total is in fact moving slowly towards 500,000 which is probably a figure politically dangerous to exceed. It corresponds roughly to a level of 3 per cent which was the rule of thumb figure taken by Lord Beveridge 20 years ago in assessing the point at which full employment had been reached. The tendency for employment to drift down slightly is not unexpected, for industrial output is doing very much the same thing, and it is doubtful if there can be a change of trend before there is a recovery in such capital goods trades as building and civil engineering. What cannot be foreseen is how far total unemployment would have to go before a serious exodus started from the foodstuffs and distribution industries and some of the service industries. It has been thought for a long time that some squeeze from these industries was necessary to get workers into the capital goods industries (including consumer durable goods). The recent performance of the motor vehicle industry has shown however that this may now be less necessary, for this industry has expanded output by raising productivity in the last two years without using significantly more labour. The best distribution of the labour force may to-day be quite different from what was wanted in 1948, ten years ago.

Opportunity and the Bulge

The output of chemical engineers is only about 250 a year and there is a demand for between 800 and 1,000 a year. So said Sir Hugh Beaver, President of the Federation of British Industries, when addressing a conference of teachers from grammar schools and technical colleges last week. At the same conference Sir Edward Boyle, Parliamentary Secretary to the Ministry of Education, emphasised the wastage of girls who had the aptitude and ability to become good engineers and scientists.

The fact is that the next few years are going to be those of greatest opportunity so far as potential recruits to technical education is concerned because the teen-age bulge will be passing through its final stages of school education. But there is every indication that the maximum effort to provide facilities for this bulge will come too late. At the moment there is a large gap between supply and demand, as Sir Hugh has pointed out. In a few years that gap may narrow, but with that narrowing the potential flood of recruits will ease off. There is therefore everything to be said for a policy of intelligent opportunism and a minimum of "perfectionism."

Busmen in the Van

London bus strikers received last week the full moral support of the TUC, who issued a statement laying the whole blame of the strike on the Government. Their finance and general purposes committee held an emergency meeting at the suggestion of Mr. Frank Cousins, general secretary of the Transport and General Workers Union.

The wording of the statement is as forthright a denunciation of Government policy as has been made by the TUC for a very long time. Clearly, it confirms the feeling of those people who saw in the London bus strike the unions' first challenge to the Government over their wage restraint policy. This is the crux of the whole issue, as is indicated by two sentences taken from the statement: the TUC believe that the strike results from "the rigid approach of the Government to wage increases which has damaged industrial relations by undermining the confidence of workpeople in the impartiality of arbitration machinery" and—even more revealing of the basic issue at stake—the explanation that the strike had been made unavoidable "by the Government's determination to hold down wages in publicly-owned industries and services, which, in times of rising prices, can only be done by cutting the living standards of the workers concerned."

The likelihood of a rail strike has never been serious after the statement (see another note on this page), for the whole of the union movement is determined to fight the Government to the finish, and prefers to do so on a narrow, relatively inexpensive, front with a strike which does not become a national emergency. Doubtless the bus strike will be made to spread if it remains ineffective, but the spread is likely to be within London only, crews on the Underground railways and automotive fuel transporters being affected.

Rail Prediction

To the time of going to press three-cornered negotiations between the Government, the British Transport Commission and the unions, dragged on but the prospects of a railways strike appeared no nearer. Developments in other directions in fact make the likelihood of a national stoppage more remote than at any time since the dispute started. One is growing unemployment, which is dampening the spirit of adventure among the rank and file of the unions and to some extent, therefore, restricting their leaders in the pursuit of an aggressive policy. The other is the apparent decision of the TUC and of Mr. Frank Cousins to fight on the relatively narrow front of London Transport.

There is, of course, another side to this—if the Government are unwilling to give their blessing to a wage increase later in the year (perhaps in consideration of certain economies and increased efficiency) union leaders may be forced to declare a strike. The railwaymen's leaders are ready for a compromise, but they must have something, if nothing concrete at least a reasonable expectation of better things to come. The leader of the NUR, Mr. Sidney Greene, expected this to be granted during a meeting early this week. On balance the odds were against a strike, and in favour of a stepped up programme of modernisation and traffic economies. In very few cases of industrial disputes has there been a better spirit of co-operation between employers and employed. But expediency, rather than goodwill, is likely to influence the course of events away from a strike.

In the Wings

While the public's attention is concentrated on the railway and London bus industrial disputes, the engineering unions are getting ready for 23 May, which is the date from which the wages "standstill" agreement with the employers negotiated last year comes to an end. At a meeting of the Confederation of Shipbuilding and Engineering Unions last week the executive were authorised to proceed as soon as possible with a substantial claim for higher wages and a demand for a shorter working week. The stage is therefore being set for a trial of strength between employers and workers in the engineering industry.

No figure has been put to the claim. The executive have a free hand—provided they produce results. At the meeting last week everybody made the right kind of noises so far as the rank and file are concerned. There was a passing swipe at the Government's economic policy and an emergency resolution about the London bus strike.

One of the ominous features of the conference was the tendency to regard the shorter working week as the heritage of the British industrial worker. It is so only if there is a very high rate of capital investment, and then it is not something to which he is entitled but something which he will earn—which is not the same thing by a long way. There was at the conference no fraternal delegate from the employers—nor was there a fraternal delegate from Japan or India either.

Where Industry Can Help

Oxford University has received an offer of £50,000, payable over a ten-year period, towards the cost of the new college which it is proposed to establish there to meet the need for more university places, particularly for more engineers and scientists. The cost of such a venture is high. In addition to the considerable expenditure involved in building, some part of which may be borne by the University Grants Committee, it is hoped to raise a sum of £500,000 for an endowment to provide scholarships and fellowships as well as to meet overhead expenses. The gift mentioned above is from Mullard Limited, the telecommunications firm.

In a speech to Convocation in October, 1957, the Vice-Chancellor referred to the proposal for founding the new college. So far as undergraduates are concerned the college will replace St. Catherine's Society and the buildings of the Society will become available as a post-graduate centre. Ultimately, it is expected that the college will accommodate 400 students of whom perhaps half will be scientists, mathematicians or engineers. While it is fully intended that the college shall be in the Oxford tradition it will offer a larger proportion of places to non-arts men than has been the custom at the University hitherto.

Companies in the News

Tilling's Growing Empire

In a cheerful and vigorous speech to the shareholders of Thomas Tilling Limited, their chairman, Mr. Lionel Fraser, condemned people who spend their time in gloomy predictions. "In Tilling's," he said, "we constantly seek ways of going ahead" and "we are not interested in the blues." The group have grown at a phenomenal rate since the end of the war: in 1949—the first year after their transport interests had been nationalised—profits amounted to only £570,000; in 1957 they totalled £1,984,000 and had increased year by year in a sturdy upward curve. Mr. Lionel Fraser expressed his company's belief that they perform "a rare and beneficial service to the community" and said they derived encouragement from this.

Tilling's are in insurance, textiles, engineering, building materials, glass, car distribution, electrical equipment, hire purchase finance, publishing and many other fields. This, Mr. Lionel Fraser said, provides them with "a good measure of insurance" against a downturn in economic conditions. The group has been built up to provide a wide spread of activities ranging over the whole field of British industry and commerce. The profit record demonstrates convincingly enough that this policy has paid handsomely. As former chairman of Babcock and Wilcox, Mr. Lionel Fraser knows very well the problems of the engineering industry. The fact that he does not hesitate to mix engineering with finance, publishing and insurance, suggests that there is some important point to be made. Perhaps it is that manufacturing activities, even in several fields, are not enough to serve as a stable basis for expansion.

Aluminium Hopes and Fears

The past year saw a turning point in the development of the aluminium industry: after ten years of efforts on the part of the leading producers to catch up with demand for their products they are now faced with an urgent need to develop sales to keep up production. The production of aluminium is "capital intensive" and any fall in output below capacity tends therefore to hit profits very hard. Two factors have combined to depress the industry in recent months: the recession in North America and the emergence of competition from countries in the Soviet bloc, notably Russia—a point made in a Weekly Survey note this week.

In their annual reports, the chairmen of Aluminium Limited—who dominate North American production—British Aluminium and Aluminium-Industrie-Aktien Gesellschaft Chippis (Schweiz) who operate in several countries on the Continent, have discussed the position. Mr. Nathanael Davis of Aluminium Limited, considers that the industry is in a period of transition and that there is a likelihood of supply exceeding demand for some time. Between 1948 and 1957 the production of primary aluminium in the world rose from approximately 1·4 million tons to 3·7 million tons and there are plans to build additional capacity of 1·5 million tons in various parts of the world, bringing up the total to something over 5 million tons. The company have also reported a very sharp fall in earnings during the first quarter of this year as compared to 1957—5·3 as against 14·9 million dol.

The recent price reduction from £197 to £180 a ton for aluminium ingot (after years of stability) was designed to stimulate demand by strengthening the competitive position of the metal. Viscount Portal, chairman of British Aluminium, criticised this as being unlikely to have long-term beneficial effects, since it will not "enable newly installed capacity to generate sufficient funds for healthy expansion." Yet with so much dependent on capacity output price cuts are inevitable—provided of course that they have the desired effect on demand. Aluminium's main hopes lay in the development of specific bulk uses, for containers and closures, building construction, motor car manufacture and shipbuilding. Intensive market research is going on to make up for the loss of demand from the aircraft industry. There is justification enough for Viscount Portal's expression of "complete faith in the long-term expansion of the industry."

Aircraft Prospects

The problems of aircraft manufacturers are far from solved, as was indicated in a searching article in last week's issue based on the inquiry undertaken by ENGINEERING. It is also plain from the recent statements by chairmen of companies in the industry, though the latest—by Mr. W. E. Nixon of de Havilland—is confident enough of his company's long-term prospects. But even they are studying carefully "other fields of industry" in which their experience can be put to useful purpose.

De Havilland have a sound order book, with orders coming in for the Comet 4, and the DH 121 jet airliner order for BEA. Yet the drop in trading revenue is continuing and is unlikely to be reversed during the current financial year. The company, like others in the industry, have been very hard hit by the reduction in Government help in financing research and development. This and the huge build-up of work-in-progress (mainly in connection with the Comet 4) have been the major factors in the Group's reduced profits.

Preliminary figures for Bristol show that the Britannia has, like the Comet 4, placed a considerable strain on available financial resources. This universal need for financial strength and for a turnover sufficient to absorb the research and development burden handed back to the companies by the Government suggests that the integration of the industry must go on as quickly as possible. The progress made in recent months by American competitors in world markets is said to be due largely to the extremely strong financial backing given to their sales drive. The recent merging of the engine interests of Hawker and Bristol is a step in the right direction. Further integration and rationalisation is inevitable, now that the Government's policy has been announced.

Bearings' Fine Balance

Manufacturers of ball and roller bearings have done very well for themselves last year and are unlikely to emerge very much worse from the current financial year. Three of them have published their results recently: British Timken, Hoffmann, and Skefko Ball Bearings. Each had higher turnover and higher profits. Hoffmann's profits rose by £200,000 to £1·2 million and turnover was a record. Their chairman, Mr. J. W. Garton, spoke of 1957 as a year of great activity—affected by increased demands from the motor industry—during which they benefited from new plant and machinery installed over the past few years. The chairman of Skefko, Sir Victor Mallet, makes the same point, saying that the expenditure of large sums in developing and improving manufacturing facilities have been fully vindicated by the results. Profits rose £150,000 to nearly £597,000. British Timken likewise showed a gain in profits of about £100,000 to £873,000.

Despite these results it would be wrong to assume the bearing manufacturers have had no difficulties. As Sir Victor Mallet rightly says, they have experienced a succession of troubles in recent years and expansion has not been easy, but expansion has taken place nonetheless. Mr. Garton considers that his company's trade is "well balanced over many industries" and sees "no reason to suppose, unless anything unforeseen happens, that we should not have a reasonably successful year in front of us." This is a good indication of the basic strength of the engineering industry.

Nickel in Over-Supply

The nickel producing industry is under severe stress, due to a heavy fall in United States demand, particularly for defence stockpiling by the United States Government. The chairman of the International Nickel Company of Canada, who are by far the largest producers in the world, Dr. John F. Thompson, told shareholders at their annual meeting in Toronto that the company had been forced to reduce production during the first quarter of 1958 to avoid stocks building up to excessive proportions. "The market for nickel," he said, "started the year in 1957 with an over-demand so substantial that some consumers continued to pay premium prices to obtain the supplies they urgently needed. It ended with nickel in over-supply." Last year nickel supply to the United States totalled 295 million pounds—the largest ever—and was 50 million pounds greater than demand.

Dr. Thompson reported that his company are going ahead according to schedule with their Manitoba project and also with expansion in Ontario. Together these plants will increase the company's capacity to 385 million pounds by 1961, and are—in the company's view—"essential to the development of a future increased market for nickel." Capital expenditure in 1958 is scheduled at between 60 million and 70 million dol, compared with 43 million dol last year and 23 million in 1956.

On the outlook for nickel, Dr. Thompson expressed his confidence, though he made clear that further progress would be brought about only by considerable efforts on the industry's part: "primarily through research for and development of new applications and markets, world-wide sales efforts and distributing facilities, and a planned programme of technical service, advertising and publicity to acquaint and advise customers and potential consumers how to use nickel profitably and to the best advantage." Nickel users are likely to be well looked after.

Rolling Stock on the Mend

The prospects of companies engaged in building railway locomotives and wagons appear to be improving: tenders are even now being invited for another 450 diesel locomotives of various types. They will certainly improve considerably—and without delay—if the British Transport Commission's plans for the modernisation of the railways are restored to their original level. Speaking before the negotiations between the Commission and the Government, Mr. T. A. Crowe, chairman of the North British Locomotive Company, said that the level of orders already booked was sufficient to employ the company fully for some time to come. Another in the industry, G. D. Peters and Company, reported a high level of activity in rolling-stock components, particularly in vacuum brakes.

The large orders placed by British Railways are enabling firms in the rolling-stock industry to become more competitive in overseas markets, by helping to remove what Mr. Crowe called "the grave handicap" which the locomotive builders have suffered in the past through not being able to show prospective overseas purchasers locomotives of their own design in service. North British Locomotive Company have had a hard time in recent years, and made a loss again last year—though a small one and much lower than in 1956—but they are gradually improving their basic position. Mr. Crowe's report suggests that they will become profitable in 1958 with very fair prospects over the next few years, provided they are able to recruit and train sufficient skilled labour to enable them to fulfill their delivery programme.

Atomic Review

General and Particular

Two aspects of atomic energy are touched on to-day. One concerns fission; the other, fusion. Together, they underline the different states of development of each as a profitable power source. Power from uranium fission being an engineering fact in this country, many firms are engaged on nuclear power projects. A table is given here to indicate the membership of the various consortia and the work undertaken by each. Power from the fusion of deuterium being largely a subject for conjecture, the particular form that an engineered fusion plant will take is far from clear. Notes describing four general lines of approach are given below.

It is perhaps significant that Britain's firm lead in the construction of nuclear power stations stemmed from an early decision to concentrate on one particular form of reactor, the Calder Hall type. Britain appears to be following this policy in fusion research too—pinched discharges have been publicised as the only approach on which major effort is being expended. On the other hand, the United States fission power programme has been characterised by a more general approach and, as the following notes show, in fusion, too, various paths of research are being followed. The greater co-operation that is said to be taking place between the two countries over fusion, compared with fission, may well prevent history repeating itself. Whatever the outcome, it will be some years before we are able to publish particulars of consortia engaged on fusion engineering.

Four Paths to Fusion

As mentioned previously in Atomic Review, the United States project Sherwood pursues research on thermonuclear fusion along four separate paths. Early this month the first details of three of them were released. Previously only the pinch method has been disclosed, it being the method employed in Zeta. Of the remaining three methods now announced none employs catalysis of fusion by muons.

The pinch method is being investigated in the United States at Los Alamos, Berkeley and Livermore. In the radiation laboratory of the University of California at Livermore, a team led by Dr. Post is investigating what is called the "mirror" approach. This is shown diagrammatically in Fig. 1. Dr. A. E. Ruark, chief of controlled thermonuclear research of the Atomic Energy Commission, described the function of the equipment as follows: "Energetic ions, with accompanying electrons, are injected into a strong field provided by two large coils. At first, the ions run on spirals nearly at right angles to the field. Then the current in the big coils is increased. This squeezes the hot gas. In different designs, it is possible to squeeze the gas radially, and to push it together along the axis. It is also possible to push the gas from one chamber to another."

At Princeton experiments are being made with stellarators. In these tubes, which are similar in some instances to the familiar torus of Zeta, a high current discharge is initiated and then shaken with very strong alternating magnetic fields. This heating process is called magnetic pumping. It was shown by Dr. Spitzer that under these conditions the gas would drift to the walls and he showed that, in order to overcome this loss of gas, the torus should be twisted into a figure of eight shape. Later it was found that good confinement could be achieved in a torus by careful design of the magnetic field. Both shapes of discharge tube have been under study at Princeton. A larger and more powerful stellarator, the Model C, is expected to come into operation in 1960.

At Oak Ridge National Laboratory a beam of energetic ions is injected into a high current arc. The arrangement is shown in Fig. 2. Mirror coils are again used. The molecular ions entering the arc are dissociated into an atomic ion (a deuteron) and a neutral atom (deuterium). The atoms escape but the hot ions are deflected into small circular orbits (Fig. 3) and contained within the magnetic field. Much depends on the efficient dissociation of the molecular ions. So far, work on this method has been done with continuous injection into mirror coils fed by direct current. Because of this, the apparatus is called the DC experiment, or DCX.

Supporting work for these programmes is done by the Naval Research Laboratory, New York University, several other universities, and industrial companies. All the main laboratories in the programme are preparing detailed papers for the Second International Conference on the Peaceful Uses of Atomic Energy, to be held at Geneva in September this year.

MEMBERS OF UNITED KINGDOM NUCLEAR POWER GROUPS

(A) NUCLEAR POWER INDUSTRIAL GROUPS

Name of consortium	Participating companies	Head office	Remarks
A.E.I.-John Thompson Nuclear Energy Co. Ltd.	British Thomson-Houston Co. Ltd. Metropolitan-Vickers Electrical Co. Ltd., and John Thompson Ltd., in association with Balfour, Beatty & Co. Ltd., and John Laing & Son Ltd.	Radbroke Hall, Knutsford, Cheshire.	Has received the contract for one of the first commercial nuclear power stations to be built for the United Kingdom electricity authorities—that at Berkeley in Gloucestershire. Has designed and is building MERLIN research reactors at the A.E.I. Research Establishment, Aldermaston Court, and for the Atomic Weapons Research Establishment and also in Western Germany. Is carrying out fusion research.
Atomic Power Constructions Ltd.	Crompton Parkinson Ltd. (electrical equipment) Elliott Brothers (London) Ltd. (instruments and control equipment) The Fairey Aviation Co. Ltd. (reactor components, fuel handling equipment, etc.) International Combustion Ltd. (steam-raising equipment) Nuclear Civil Constructors (being a partnership of Trollope & Colls Ltd. and Holland & Hannen and Cubitts Ltd.) Richardsons, Westgarth & Co. Ltd. (generating plant)	28 Theobalds Road, London, W.C.1.	Formed late in 1956 after the first contracts had been awarded by the United Kingdom Electricity Boards. At present actively engaged in the preparation of tenders for the next inquiries to be issued by the CEGB. Babcock and Wilcox will supply large pressure vessels.
English Electric-Babcock & Wilcox-Taylor Woodrow Atomic Power Group	English Electric Co. Ltd. Babcock & Wilcox, Ltd. Taylor Woodrow Construction Ltd.	Inquiries to: the English Electric Co. Ltd., Cambridge Road, Whetstone, near Leicester *or* Babcock and Wilcox, Ltd., Babcock House, 209 Euston Road, London, N.W.1.	Has received the contract for a 500 MW commercial nuclear power station to be built at Hinkley Point. Babcock and Wilcox were principal contractors at Calder Hall and Chapel Cross, where they were responsible for the design and construction of all heat exchangers. Taylor Woodrow were the main civil contractors for the Calder Hall station.
G.E.C.—Simon-Carves Atomic Energy Group	General Electric Co. Ltd. Simon-Carves Ltd. The Motherwell Bridge & Engineering Co. Ltd. John Mowlem & Co. Ltd.	The General Electric Co. Ltd., Atomic Energy Division, Erith, Kent.	Has been awarded the contract for the South of Scotland Electricity Board's first nuclear power station, at Hunterston, Ayrshire, Scotland. G.E.C. has received a contract from the UKAEA for a large part of the design and construction of the zero-energy assembly for a high-temperature gas-cooled reactor system. This is to be built at the Authority's new research station at Winfrith Heath. Motherwell Bridge and Engineering were responsible for the erection of the 135 ft diameter containment sphere for the fast-breeder reactor at Dounreay. G.E.C. is supplying and installing the 15 MW turbo-alternator for this reactor.
Hawker Siddeley-John Brown Nuclear Construction Ltd.	Hawker Siddeley Group and John Brown & Co. Ltd. companies (numbering more than 100 operating companies)	4 The Sanctuary, London, S.W.1.	Formed to act as the focal point for the resources of the operating companies of the two groups in the nuclear reactor field, both on land and sea.
Nuclear Power Plant Co. Ltd.	C. A. Parsons & Co. Ltd. (turbo-generators, transformers, condensers, feed heaters, circulators, duct work, instrumentation) A. Reyrolle & Co. Ltd. (switchgear, control gear) Head, Wrightson & Co. Ltd. (reactor equipment, heat exchangers) Sir Robert McAlpine & Sons Ltd. (civil engineering) Whessoe Ltd. (pressure vessels) Strachan & Henshaw Ltd. (fuel-handling equipment) Alex. Findlay & Co. Ltd. (structural steel, general fabrication) Clarke, Chapman & Co. Ltd. (steam-raising equipment, cranes and lifting equipment) Parolle Electrical Plant Co. Ltd.	*Head Office:* Booths Hall, Knutsford, Cheshire. *Registered Office:* Heaton Works, Newcastle upon Tyne, 6, Northumberland.	Has been awarded the contract for the Bradwell commercial nuclear power station in Essex. The group has also received letters of intent for the construction of a 200 MW nuclear power station in Italy. Parolle Electrical Plant Co. Ltd. were engaged upon the feasibility study which preceded the decision to detail, design and construct Calder Hall "A" nuclear power station. At Calder Hall, six of the eight member companies supplied major items of equipment: C. A. Parsons & Co. Ltd., turbo-generators and condensers, gas circulators and ducts. A. Reyrolle & Co. Ltd., switchgear and control boards. Head, Wrightson & Co. Ltd., bellows units and auxiliary ducting. Whessoe Ltd., reactor pressure vessels. Strachan & Henshaw Ltd., fuel-handling equipment. Alex. Findlay & Co. Ltd., structural steelwork. Member companies also played a part in the construction of the Chapel Cross station and the Atomic Energy Research Establishment, Harwell. Head, Wrightson was awarded the contract for a heavy water research reactor for the Australian Atomic Energy Commission and is building similar reactors for Denmark and Germany, costing about £750,000.

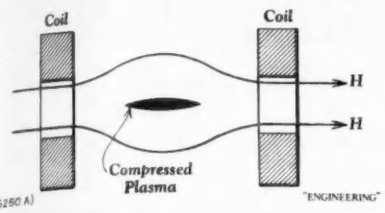


Fig. 1 In the "mirror" approach, energetic ions are injected into a strong field provided by two large coils. Then the current in the coils is increased and the field squeezes the gas.

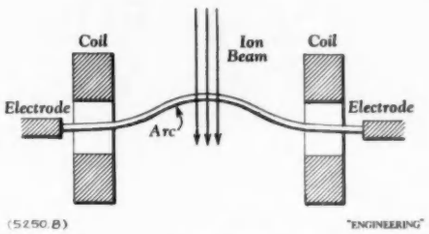


Fig. 2 In the "DCX" approach, energetic deuterium molecular ions are fired into an arc.

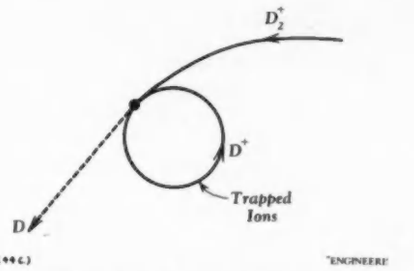


Fig. 3 The arc dissociates the molecules and atomic ions are trapped inside a magnetic field.

(B) Other Groups Engaged in Nuclear Energy Research and Production

Name of consortium	Participating companies	Head office	Remarks
Babcock & Wilcox Ltd., 209 Euston Road, London, N.W.1. Cammell Laird & Co. (Shipbuilders and Engineers) Ltd., Birkenhead.			These two companies have been collaborating on the nuclear propulsion of ships since April, 1956.
de Havilland Engine Co. Ltd.		Leavesden Aerodrome Leavesden, Herts.	Now participating in the development of small high-temperature gas-cooled reactor power plants, suitable for propulsion and transportable generating sets.
Hawker Siddeley Nuclear Power Co. Ltd.		Sutton Lane, Langley, near Slough, Bucks.	Carries out design and experimental work on reactor systems for Hawker Siddeley—John Brown Nuclear Construction Ltd., and research and development work on general reactor problems, particularly in the metallurgical and chemical fields, for reactor systems of advanced character. It is suitably placed for undertaking special reactor studies.
Humphreys & Glasgow Ltd.	Humphreys & Glasgow Ltd. Daniel Adamson & Co. Ltd. Alco Products Inc.	Humglas House, Carlisle Place, London, S.W.1.	Humphreys & Glasgow market nuclear power stations incorporating a pressurised water reactor designed by Alco Products Inc. These stations are suitable for electricity generation in capacities up to 20 MW(E) or for the corresponding supply of steam, or a combination of both. The nuclear plant would be manufactured by Daniel Adamson to Alco's designs; the remaining plant being obtained from the most appropriate source, having regard to the location of the station.
Mitchell-A.M.F.	Mitchell Engineering Ltd. A.M.F. Atomics Inc.	1 Bedford Square, London, W.C.1.	Mitchell Engineering Ltd., A.M.F. Atomics Inc., and General Nuclear Engineering of Dunedin, Florida, as consultants, offer boiling water reactors with outputs of 17·5 to 70 MW (electrical); the 70 MW sets can be paired to form larger 140 MW stations. Mitchell Engineering are the main contractors and, through their fully owned subsidiary, the Mitchell Construction Co., Ltd, are the major civil contractors to the UKAEA for the nuclear power station at Chapel Cross, Dumfriesshire.
Ruston & Hornsby Ltd., Lincoln. J. L. Kier & Co. Ltd., 7 Lygon Place, Grosvenor Gardens, London, S.W.1.			Have agreed to collaborate on the design, development and building of nuclear power stations of 5 to 25 MW electrical capacity. A combined design team has been set up at the Ruston & Hornsby works.
Turriff Construction Corporation Ltd.		Budbrooke Road, Warwick.	Late in 1957 were appointed the main civil engineering contractors for the external works, foundations, sewerage, reservoir, water treatment and service mains at Winfrith Heath research establishment, Dorset, for the UKAEA and, in January last, were appointed the main contractors for various buildings at Winfrith Heath.
Vickers Nuclear Engineering Ltd.	Vickers Ltd. Rolls-Royce Ltd. Foster Wheeler Ltd.	Vickers House, Broadway, London, S.W.1.	Formed in February, 1956, to work on the application of nuclear energy to marine propulsion. Engaged on Admiralty contracts for the prototype set of nuclear submarine machinery and for the first nuclear submarine, H.M.S. Dreadnought: Rolls-Royce will be responsible for the reactor, and have already constructed the reactor NEPTUNE at Harwell.
Anglo Great Lakes Corporation Ltd.	C. A. Parsons & Co. Ltd. A. Reyrolle & Co. Ltd. Sir Robert McAlpine & Sons Ltd. Clarke, Chapman & Co. Ltd. Great Lakes Carbon Corporation (New York)	*Head office:* Heaton Works, Newcastle upon Tyne 6. *Factory:* Newburn, Newcastle upon Tyne	Manufacture of nuclear graphite.
British Acheson Electrodes Ltd.		Grange Mill Lane, Wincobank, Sheffield.	Produces "Acheson" graphite for nuclear reactor moderators.
Nuclear Graphite Ltd.	A.E.I.-John Thompson Nuclear Energy Co. Ltd. Morgan Crucible Co. Ltd.	52 Battersea Church Road, London, S.W.11.	Specialise in the accurate machining of components for graphite moderators.

(C) Government and Other Bodies

Ministry of Power, Thames House South, Millbank, London, S.W.1.
Central Electricity Generating Board, Bankside House, Sumner Street, London, S.E.1.
United Kingdom Atomic Energy Authority, 11 Charles II Street, Lower Regent Street, London, S.W.1.
Nuclear Energy Trade Associations' Conference, 32 Victoria Street, London, S.W.1.
British Nuclear Energy Conference, 1-7 Great George Street, London, S.W.1.

(D) Consultants

Kennedy and Donkin, 12 Caxton Street, London, S.W.1.
Merz and McLellan, 32 Victoria Street, London, S.W.1.
Ewbank and Partners Ltd., 10-11 Grosvenor Place, London, S.W.1.
Preece, Cardew and Rider, 8-12 Queen Anne's Gate, London, S.W.1.

These firms of consultants are working with the UKAEA, the Central Electricity Generating Board, and with the various industrial groups on the specification, planning and inspection of nuclear power station construction in Britain. They are in a position to assist governments wanting to start nuclear power programmes, especially those which have not yet decided at what stage to introduce nuclear power into their systems. For these projects they can give independent advice on alternative schemes, possible suppliers of equipment, siting of stations, costs, and so on.

Notes and News

British Company's Agreement with Italy

The Nuclear Power Plant Company, Knutsford, on 2 May signed a formal agreement with AGIP Nucleare, Milan, for collaboration in the construction of nuclear power stations in Italy over a minimum period of seven years. This brings to a happy conclusion negotiations which have been in progress since February of last year and covers the exchange of information on the design, construction and operation of nuclear power stations, the training of technical staff and collaboration in research.

The signatories to this agreement were Signor E. Mattei, president of AGIP Nucleare, and Sir Claude Gibb, chairman of the NPPC. Formed in 1957, AGIP Nucleare is one of five main concerns which go to make up the Italian state-controlled organisation Ente Nazionale Idrocarburi (ENI).

As it stands, this agreement is not a contract for a nuclear power station, but it does anticipate the signing of another contract in the next few weeks, for the construction of a 200 MW nuclear power station with a single graphite-moderated gas-cooled reactor. The Società Italiana Meridionale per l'Energia Atomica (SIMEA), a company 75 per cent controlled by AGIP Nucleare, is expected to begin work on the site of this power station in July, and the completion date has been given as 1962. It will be located at Latina, about 40 miles south of Rome—it was originally intended to be built in northern Italy—and will cost over £20 million, of which more than half will be spent in Italy.

AGIP will undertake the civil engineering and building work in close co-operation with the Nuclear Power Plant Company, and will also be responsible for the manufacture and testing of all components made in Italy. The British company will be responsible for the overall design of the station and for its satisfactory commissioning, and will supply the major components, including the reactor itself with its ancillary equipment, the boiler heat transfer elements and the turbines. The U.K. Atomic Energy Authority will continue to act as consultants on many aspects of the project and an agreement for nuclear fuel supplies has been ratified recently by the British and Italian Governments.

In February AGIP Nucleare set up a laboratory for applied research and the long-term agreement for collaboration is intended to provide every assistance in the building up of their own technical knowledge and in the training of technicians. The NPPC feel that by strengthening ties in this way, although it may mean the eventual loss of contracts for the simpler and less specialised plant and equipment which the Italians will be able to build themselves, it will enable us to exercise an influence by selling the more specialised and complex products which are the fruits of our own research and development.

Italy plans to construct nuclear power stations to provide 2,000 MW by 1967—that is the equivalent of ten stations like the Latina station. The importance of establishing a foothold in the Italian market must not therefore be under-rated.

Continuing Atomic Review

Argonne Exhibits at Brussels

The Argonne National Laboratory, United States, selected to display atomic age "tools" at the World's Fair in Brussels. In the International Science Section is displayed a working model of a continuous countercurrent liquid-liquid extraction system, involving the separation of uranium and copper. This system was developed in Argonne's chemical engineering division.

New electronically-controlled master-slave servo-manipulator "mechanical hands" and three-dimensional television are on display in the United States Pavilion, where there is a mock-up of a shielded hot-cell with windows. The master-slave servo-manipulators enable a scientist to handle complex experimental operations inside the thick, heavy walls of the cell almost as well as with his own hands, without exposing himself to the dangers of radiation. The manipulators reproduce the basic motions of the human hands and reflect back to the operator the forces which are exerted at the slave, thereby giving him a sense of touch. Electronically controlled servo-mechanisms replace the mechanical connections which have been used in earlier manipulators and enable the two arms of the manipulator to be connected by electric wires or a radio link. In the exhibit, an overhead, remotely controlled bridge and rail system, allows the manipulators to be placed in any part of the hot-cell. The exhibit also will show how a scientist can see his work either directly through a thick shielding window, or by a stereo television system.

A 100 channel pulse-height analyser which was developed in Argonne's electronics division is being displayed by a commercial firm. This instrument is a research tool and is mainly used to determine the energy and number of gamma rays emitted from a radioactive source.

New Journal—Nukleonik

The first number of a new German scientific journal, *Nukleonik*, appeared in April. It is published by Springer-Verlag/Berlin, Göttingen, and Heidelberg, and will have an eminent editorial staff, not only of German specialists but also of specialists in this field from neighbouring European countries. As the name of the journal implies, it is intended to cover the whole field of nuclear engineering and to keep readers in touch with scientific and technical developments in this and allied fields.

Nuclear-Powered Ships

Swan, Hunter and Wigham Richardson and the Nuclear Power Plant Company announced on 6 May that they are entering into collaboration for the design and construction of nuclear-powered ships. Swan, Hunter and Wigham Richardson are world-famous as designers and builders of passenger and cargo ships, and have considerable experience in the construction of large oil tankers.

Growth of the Atomic Industry

The Atomic Industrial Forum, New York, announces the publication of "Growth Survey of the Atomic Industry, 1958-1968". The 84-page report is intended as a guide to companies and organisations wishing to undertake market studies of the atomic energy industry.

The report is divided into 12 main sections and includes more than 50 charts and tables. The sections cover: Nuclear Power Projections; Growth Rate; Capital Costs and Overall Estimates for United States Large Power Reactors; Naval, Military and Propulsion Reactors; Small Reactors; Volume of Reactor Business in the United States; Factors Affecting Foreign Nuclear Power Growth; Volume and Business Potential of Large Foreign Nuclear Power Plants; Fuel and Fuel Processing Requirements; and Major Reactor Components.

Copies may be ordered from Atomic Industrial Forum, 3 East 54th Street, New York 22, New York. Publication price: 25 dol per copy.

NEW FOR TELEVISION

A Short Cathode-Ray Tube for Monochrome and Colour

It was an advertisement showing a futuristic television set hanging on the wall that started the development of the cathode-ray tube described in a paper by Dr. D. Gabor, Dr. P. R. Stuart, and Mr. P. G. Kalman, and presented to the Institution of Electrical Engineers on 14 May, under the title of "A New Cathode-ray Tube for Monochrome and Colour Television." Extracts from this paper are given below. (Fig. 1 was obtained from another source.) Although more expensive in itself than the conventional tube, some economies in circuit design and cabinet construction result; but the chief advantage undoubtedly lies in the simplicity with which it can be used for colour reproduction. It thus offers the combination of two steps in one—from monochrome to colour and from cods-eye to flat screen, which can be hung on the wall.

The technical advances of the flat tube lie in the electron optics and the automatic self-scanning system involved; the major part of the paper was devoted to these aspects. Although the tube has hardly left the laboratory stage the designers, all of whom are at Imperial College of Science and Technology and who have been working on the project in conjunction with the National Research Development Corporation, have given some thought to the manufacturing problems and have briefly indicated how they may be met. Thus it would seem that the tube is ready for commercial development. As regards the circuit, beyond saying that it could be contained in an additional 2 in of depth, making the complete set, for a 12 in diagonal screen, about 20 in square by 6½ in deep, the authors say nothing in this paper but state that it will form the subject of later publications. Design data and theory of the reversing lens, magnetic collimator and the self-scan are given in appendices to the paper.

In conventional cathode-ray tubes the beam approaches the screen in a straight line, like a pencil pivoted at its end. In the new flat tube, the beam is folded over on itself, and runs for most of its length parallel to the picture screen, bending towards it only on the last short section of its trajectory.

The tube, shown schematically in Fig. 2, is an all-glass version of a colour television tube. It is essentially a flat glass box, with a depth of about 3½ in outside and 2 in inside, for a screen with 12 in diagonal. It is divided in depth by a base-plate, on which are mounted all the electrode structures, and which, in turn, is carried by four elastic metal rods let into the joint of the two glass shells. It is preferable to make this plate of a material with high magnetic permeability, such as Permalloy, so that it may act at the same time as a very efficient magnetic screen.

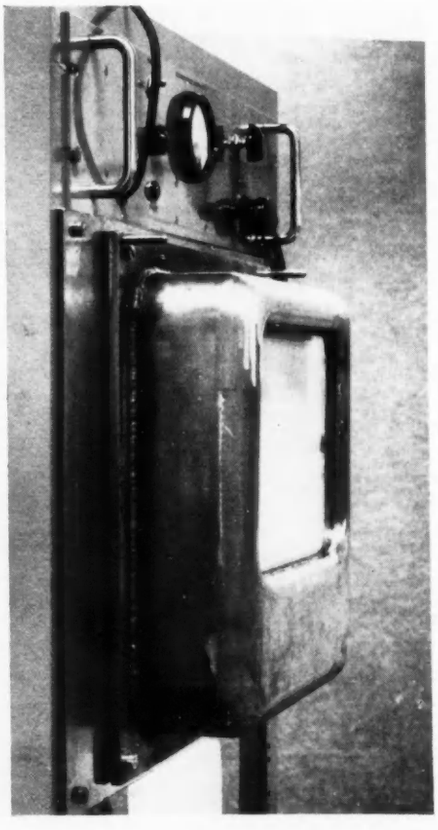


Fig. 1 The new cathode-ray tube requires a depth of only 4½ in for a 12 in diagonal screen.

The electron gun can be a conventional type in the monochrome version; the special gun for colour tubes will be described later. It is mounted behind the partition, near the top, and launches the electron beam vertically downwards. The beam passes through the line- or X-deflection plates, so that it swings parallel to the plane of the base-plate, in the rhythm of the line scan, with an angular excursion of about ± 15°.

The gun and X-deflectors are more or less conventional, but the beam next passes into a new type of electron-optical element, called the reversing lens, which rotates the plane formed by the fan of rays issuing from the deflector by 180°

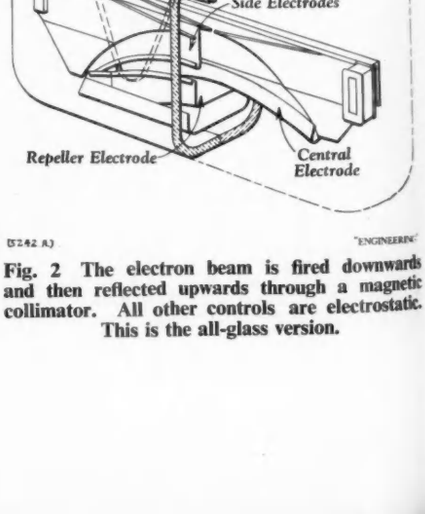


Fig. 2 The electron beam is fired downwards and then reflected upwards through a magnetic collimator. All other controls are electrostatic. This is the all-glass version.

into another plane, parallel to the picture screen, while increasing the divergence angle of the fan by a factor of about 4. This means that, on leaving the reversing lens, the deflected rays sweep through an angle of about 120°. Owing to this large divergence, the beam sweeps out the whole horizontal width of the picture only a few inches above its lowest point. At this level the beam passes through another novel structure called the collimator, which is the only magnetic element in the otherwise purely electrostatic electron-optical system. This can be considered as a very powerful flat lens, which collimates the rays, i.e., it sends the beam exactly vertically upwards, into the space between the base-plate and the luminescent screen.

The base-plate carries near its front face and spaced from it by a few millimetres, an electrode structure called the scanning array. The purpose of this device is to bend the beam towards the screen at a certain level, at the same time focusing it, and to sweep this level downwards at the speed of the vertical scan.

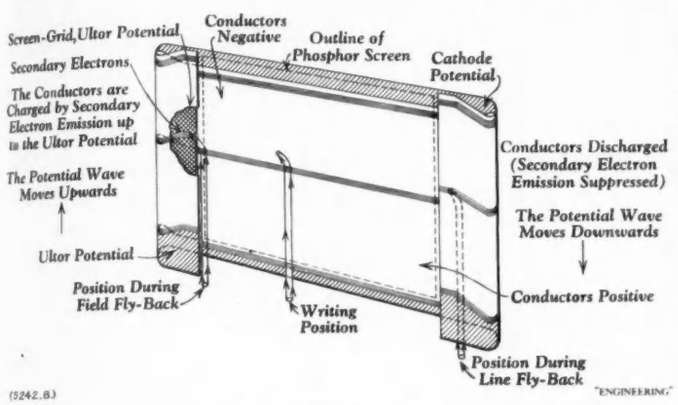


Fig. 3 (left) Self-scanning is achieved by a series of charged conductors, staggered at the ends. These are discharged in turn by the passage of the beam, which is thereby deflected and focused on the screen.

Fig. 4 (right) Colour production is obtained by a shadow mask and successive lines of colour phosphors activated by the three beams. The mask is only about 0·02 in from the screen.

As seen in Fig. 3, the scanning array consists of a large number (about 100) of thin linear conductors—which can be realised for instance by metal strips printed on an insulating base—that are not electrically connected to any circuit. They are charged and discharged by the writing beam itself, as will be explained later. For the present, let us assume that up to a certain level (the lowest of the group of four lines explicitly shown in the middle of Fig. 3) the conductors are charged up to the maximum positive potential V_m, which is also the potential of the luminescent screen. Up to this level, therefore, the electron beam proceeds vertically. Above a certain level (the top line of the group of four) the potential may be, say, $\frac{1}{4}V_m$, i.e., strongly negative with respect to the screen, while the four lines themselves represent a transition region. The trajectories will then curve towards the screen in this region. It is seen that the beam is not only bent but focused; this is the effect of "deflection focusing," which is well known in television tubes as a serious disadvantage of electrostatic deflection, and is here made to serve a useful purpose. It is also the basis of colour production in the flat tube.

SELF-SCANNING

Fig. 3 illustrates also the second function of the array—the vertical or frame scan which is effected by the writing beam itself. The scanning array forms U-shaped loops at both sides of the picture area, and in this region the conductors are slanting upwards, terminating in horizontal sections, which are staggered upwards by a certain amount relative to their long, horizontal central sections. As long as the beam remains inside the picture area, the charge of the conductors remains unaltered, and hence the spot describes an exactly straight horizontal line. But when a line scan is finished, the beam moves into the loop at the right-hand side, and here, if the stagger is properly dimensioned, the beam will spray one or several conductors in the transition region. The area opposite this is at a lower potential and acts as a suppressor of secondary electrons. In consequence, the sprayed conductors are discharged by the full amount of negative electron charge which they collect from the beam. This causes the transition region to move downwards, and hence the next line sweep of the spot will be at a somewhat lower level. If the beam current during the time between two line sweeps, while the beam rests in the loop at the right, is properly dimensioned, the spot will move down just by a step of the desired length.

When the beam has run down and the array is discharged, it is recharged again by the writing beam. This is done by stopping the line scan and moving the beam into the loop at the left-hand side. This differs from the other loop by a somewhat larger stagger and by the presence of a screen grid between the beam and the terminal portion of the array. This screen grid is maintained at the maximum positive potential V_m, called the "ultor" potential, and therefore acts as a collector of secondary electrons. If the secondary yield, δ, of the array conductors exceeds unity, the effect is as if $\delta - 1$ positive electrons had landed on it instead of one negative electron, and the conductors charge themselves up gradually to the screen-grid potential V_m, while the beam moves upwards, to the top.

A metal strip called the "C-plate" is arranged at the top, and maintained permanently at a level near cathode potential. When the new frame starts, the line scan is switched on again, and the beam moves from the region of the screen grid into the region of the C-plate, which throws it against the luminescent screen. The C-plate is at such a distance from the top conductor that the scanning wave is, as it were, "preformed," so that the run-down can start automatically, with the right waveshape and at the right speed. Interlacing is effected by giving the C-plate somewhat different potentials in alternate frames, so that the scan starts at levels differing by a line spacing.

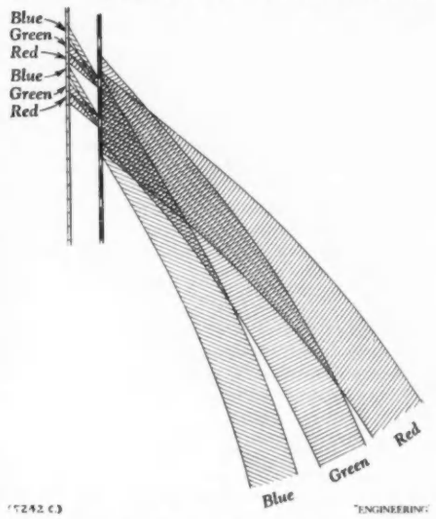
COLOUR CONTROL

A beam convergence angle of the order of 30° or 0·5 rad is quite unusual in cathode-ray electron optics; even projection tubes have convergence angles of, at the most, 0·05 rad. The reason is that, in the flat tube, the spot is carried along, as it were, by a short-focus cylindrical lens, close to the screen, while, in conventional tubes, the focusing is effected by the electron gun, at a large distance from it.

This is the basic advantage of the flat tube in colour television, and Fig. 4 illustrates schematically how this advantage may be utilised. A shadow mask, which is essentially a plane metallic structure with evenly spaced horizontal (or nearly horizontal) slits, is placed before the screen, which carries a system of phosphor strips in the three fundamental colours, red, green and blue, with one colour cycle per slit. The phosphor strips are so arranged that, at a certain angle of incidence, or near it, the electrons excite only one colour.

This principle is well known, and has been widely used in existing colour tubes. The advantage of the flat tube is in the dimensions. In the conventional colour tubes, in which three beams produced by three separate guns converge at an angle of about 6° to one another, the distance of the shadow mask from the screen must be made about ½ in. In the flat tube, with incidence angles between 30° and 60°, the distance is 1/40 in or even 1/50 in. Therefore, in the flat tube it becomes possible to fix the mask on the screen surface itself, thus eliminating all possible distortions of the mask. Moreover, it now becomes possible, for the first time, to stick the shadow mask on the screen first and produce the phosphor lines behind it in automatic register with the slits, by a simple method which will be explained later.

There also exists a second possibility for exploiting the advantages of the flat-tube electron optics for colour production, using composite screens



formed by the superposition of three layers of colour phosphors and utilising the different penetration of electrons of different energies for differential excitation of the three colours.

Feldman and his collaborators have succeeded in producing grainless luminescent films by evaporation with very even thicknesses of the order of 1 micron, and have successfully demonstrated a two-colour screen, in which both colours could be fully saturated by a voltage swing of 8-22 keV. These almost fully transparent screens have also remarkable contrast; the picture can be viewed in a room illuminated so brightly that a picture on a powder screen becomes completely invisible. However, there are some serious disadvantages. Nevertheless, a method of producing colour-television pictures without any shadow mask or other structure before the screen, and which at the same time allows pictures to be viewed in bright rooms, is too attractive to be dismissed out of hand, even if it gives an efficiency somewhat lower than that of the shadow-mask method.

The electron optics of colour control in the flat tube is illustrated in Fig. 5, which is a section of the tube in the symmetry plane $X = 0$. It is best to look first at the left-hand side, in order to realise the conditions imposed on the system. The central rays of the three colour beams, which will be called principal rays, are shown to run vertically upwards, equally spaced from one another. They are then brought together by the deflecting field of the array in a rather small spot. In order to ensure colour purity, it is advantageous to let each colour beam be collimated in itself where it strikes the shadow mask, so that each has a definite incidence angle. This is achieved, as shown in the figure, by focusing the three beams not on the screen but a little before it, and near the rear focus of the deflection lens.

Defocusing for the avoidance of moiré effects does not mean a sacrifice of definition, because

Continuing New for Television

the shadow mask and the phosphor screen can be made with a much finer period than in other colour tubes. Shadow masks have been made with 50 lines per in (150 colour strips per in), which gives nearly 400 lines in a tube with a 12 in diagonal and about 650 lines in a 20 in tube. This would be sufficient for 625 transmitted lines for the first, and about 1,000 lines for the second size, because, in interlaced pictures, the effective definition is not more than about 60 per cent of the nominal.

The conditions to be fulfilled by the electron-optical system consisting of gun, X-deflectors, reversing lens and collimator, can be formulated as follows. The system must launch the principal rays of the three colour beams vertically into the space between the screen and the array, in three predetermined equi-distant planes. These remain stationary during the scanning process (apart from minor corrections for achieving optimum convergence, which may be left out of consideration), while the focal points of the three colour beams slide down in them with the speed of the frame scan.

While the problem of colour convergence, which presents such great difficulties in the known three-gun shadow-mask tubes, is solved almost automatically in the flat tube, the achievement of colour purity imposes stringent conditions on the perfection of the optics. The authors made these conditions even more stringent by postulating from the start that the correction of electron-optical errors must not be left to the circuit engineer, as it is in conventional shadow-mask tubes (" dynamic convergence "), and that the number of trimming devices corresponding to the numerous small correcting magnets now attached to the neck of colour tubes must be reduced to a minimum. Moreover they set themselves the task of making the magnetic screening good enough to avoid adjustments *in situ*, so as to reduce the servicing problem, which has proved such a hindrance to the spreading of colour television, and to avoid the necessity of using highly-stabilised power supplies.

Fig. 5 shows how these conditions are met in the central, $X = 0$, plane. The three-colour gun has three cathodes side by side, located in an insulating body, with a common heater. This feature makes it easier to use impregnated high-density cathodes in place of the common coated ones, and it also makes it possible to arrange another couple of cathodes spaced at right angles to the plane of the drawing. These may be used for the flyback, which requires a stronger current than the picture, and, apart from the saving in life time, such separate flyback cathodes have advantages from the point of view of the circuit engineer.

The three cathodes face a common grid and a common accelerator. Modulation is achieved by applying the signals to the cathodes, not to the grid. For the convenience of the circuit designer, all potentials used in the gun are either equal to the maximum or ultor potential V_m, or within 5 per cent of V_m from the cathode potential. The first accelerator has a potential of 0·03-0·05 V_m, and emits three beams with axes divergent by a total of about 0·25 rad. From this point onwards the gun is rotationally symmetrical. The beams enter an accelerating lens, consisting of a large-diameter tube which is called the " magnification control " and a small-diameter tube, containing a stop, which trims off the outer " halo."

For the convenience of the circuit designer, a final lens of the usual single-lens type is used, although it is well known that its spherical aberration is appreciably larger than what can be achieved in the same space by a lens of the accelerating type. Such a lens, if it is not made larger than usual, can handle one beam with fairly small spherical aberration, but not three divergent beams. It was therefore found necessary to insert between the stop and the final lens a " field lens," also of the single-lens type, called " focus control " in the figure. Thus the cross-section

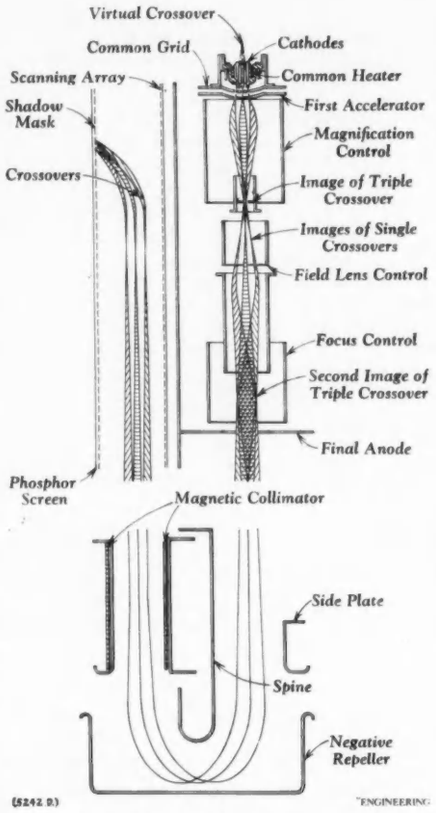


Fig. 5 To produce the three colour beams, three cathodes are used in the gun.

filled by the three beams in the last lens is not appreciably larger than that required for a single beam, and the aberrations become correspondingly small. There is, however, another important advantage achieved by this arrangement. As the second image of the triple cross-over is in the centre of the final lens, variation of the potential of the control electrode of this lens will not affect the principal rays at all, but will only make the foci glide up and down on these rays which themselves remain fixed. This is just what is required by the optics of the flat tube in the screen region. Only one potential, the voltage of the focus-control electrode, need be varied in accordance with the height of the writing spot, in the rhythm of the frame scan, and one can derive a suitable signal very readily from the scanning array itself, by coupling it capacitively with a vertical metal strip earthed through a suitable resistance.

The three colour beams leave the gun in slightly diverging directions and after passing the X-deflectors, not shown in Fig. 5, they enter the reversing lens, shown in a central cross-section. The reversing lens consists of three positive electrodes called the " spine " and the front and rear side-plates, all three at V_m, and a negative, trough-shaped electrode called the " repeller " at cathode potential. The reversing lens must turn round the central ray by 180°, and must produce such a divergence or convergence between the two side rays that, after passing through the collimator, all three rays emerge parallel and vertical. The collimator is a positive, converging lens in the plane at right-angles to Fig. 5. In the plane $X = 0$ it acts as a diverging lens, and hence the principal rays must leave the reversing lens with a certain small convergence in order to be ultimately collimated.

REVERSING LENS

The reversing lens is the most crucial device in the flat tube. Not only must it produce a family of principal rays to very exacting specifications, but almost the whole burden of correcting the focusing errors arising in the other electron-optical elements is thrown on it. The authors refused to contemplate correcting electron-optical errors by suitable modulation of potentials (" dynamic focusing ") in the belief that the simplification of circuit design would ultimately compensate for the time of development, which took over three years.

This is the list of conditions imposed on the reversing lens:

(*a*) It must rotate every principal ray issuing from the line deflector by 180° around a horizontal axis.

(*b*) It must increase the deflection angle of every principal ray by a factor of about 4. This was dictated by considerations of the saving in line-scanning circuits, and also by the consideration that electrostatic deflection by more than about $\pm 20°$ would produce focusing errors which are almost unmanageable.

(*c*) After these two rotations the principal rays must again be contained in a plane.

(*d*) The final X co-ordinate must be a linear or very nearly linear function of the line deflection voltage.

(*e*) At a set focus of the electron gun, the X-focus must remain permanently on a horizontal line, so that no " dynamical " adjustment of the gun potentials is required during a line scan.

(*f*) In the Y-direction the second-order aberration of narrow pencils centring on a principal ray must be zero. This condition must be imposed not so much in order to improve the vertical focus of the beams, which is almost automatically of good quality, but in order to ensure that the red and blue colour axes are equidistant at the two sides of the green axes.

(*g*) The third-order Y-aberration must be as small as possible. This condition is important chiefly because, since space is restricted, it is desirable to make the dimensions of the reversing lens in the direction at right-angles to the picture as small as possible, and hence it is necessary to fill a considerable part of its aperture with electrons.

(*h*) In the Y-direction the reversing lens, in tandem with the collimator, must (i) focus the cross-over of the three colour axes in the gun at infinity, i.e. turn these axes into parallel lines which must (ii) have the same spacing independently of the X-deflection.

In the flat tube with a "unipotential " reversing lens the negative trough has the largest depth of all elements, and thereby determines the thickness of the tube. Recently a further reduction of the overall thickness was achieved, by introducing an electrode at an intermediate potential, as shown in Fig. 6. In this " space-saving " design the positive electrodes (at a potential V_m) are the same as before, while the repeller is replaced by a two-electrode structure. This consists of the cylindrical repeller bottom, at cathode potential, and of the intermediate electrode, which consists of two frustro-conical metal strips, connected by two bridges at the ends. These are shaped, on the basis of experiments in the electrolytic tank, in such a way that, when the intermediate electrode is at a potential 0·1-0·5V_m, the field in the space utilised by the

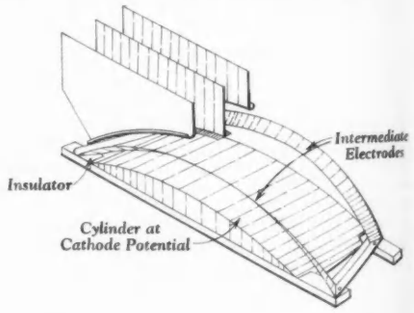


Fig. 6 Later developments of the reversing lens were simpler and more compact in design and could largely be fabricated from sheet metal.

electrons is the same as with one of the well-tried repeller troughs. The screening effect provided by the conical strips is sufficient to make the field inside very insensitive to potentials outside this structure. Fig. 6 also shows the new T-shaped spine, which represents a great improvement in third-order aberrations over the previous U-shape.

The collimator was not foreseen in the original conception of the flat tube in 1952, but it became a necessity when the self-scanning principle was introduced. It has also the advantages that it makes complicated "grouping" of the colour areas unnecessary, it evens out the spot size over the whole picture area, and makes it unnecessary to use trapezium correcting circuits. These advantages are worth the complication of using a magnetic device in an otherwise purely electrostatic electron-optical system.

The collimator is a "strong" lens, i.e. it uses a first-order effect instead of a second-order effect. It fully deserves to be called strong, because its aperture is about $f/0.5$.

The collimator shown in Fig. 7 consists of four magnetic pole-pieces, joined by two cores carrying windings. The shape of the pole-pieces is the result of many experiments. Starting from a simple triangular shape they were gradually trimmed down, until the collimation was perfect. It was found necessary to bend out the finely tapering ends in the way shown.

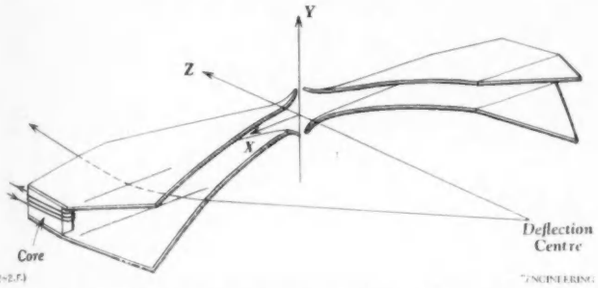


Fig. 7 (left) The design of the magnetic collimator was achieved as a result of experiments.

Fig. 8 (right) The tube need not be made entirely of glass as in Fig. 2; a metal casing and glass screen is quite practicable, as shown here.

COMMERCIAL MANUFACTURE

It is natural to ask whether a complicated structure like the reversing lens, which is specified by not less than 13 essential data, can be realised with reasonable manufacturing tolerances. However, starting with the gun, and using jigs and mandrels similar to those used in manufacture, the authors experienced no difficulty in making guns which produced three coplanar and equidistant colour beams with a cross-over in the centre of the stop. Considerable attention was given to the alignment of the deflector system, so that it produced plane ray fans instead of conical ones, and planes with unmeasurably small curvature were regularly obtained.

In order to be certain that the experiments are not marred by inaccuracies, the authors initially used spines and repeller troughs made by electroforming from accurately machined models, but later they succeeded in obtaining completely satisfactory results with all parts of the reversing lens made from sheet metal, 0·008-0·015 in thick. All electrodes were made of non-magnetic (44-56) nickel-copper alloy, with the exception of the spine, which was made of Permalloy C to screen off the stray field of the magnetic collimator. There were, however, occasional difficulties owing to the imperfect shape of the repeller bottom, and there may be an advantage in having this part made by electroforming or by chemical deposition.

On the other hand, considerable accuracy is required in aligning the positive electrodes of the reversing lens with the repeller, which cannot be achieved in sheet-metal work, and from the start, necessity of small electrical corrections by "trimmer" electrodes was foreseen. There are altogether five parameters which may require small corrections, one of which may not be necessary if the sheet metal work is of sufficiently high quality.

The flat tube raises manufacturing problems mainly by reason of two of its new elements, the scanning array and the shadow mask fixed on the phosphor screen, but also by its flat screen and box-shaped envelope.

A self-supporting scanning array has been designed. Fairly thin tapes, 0·125 in by 0·005 in, of nickel-copper alloy or Nichrome are drawn to a semi-circular cross-section so they become stiff enough to support themselves between two insulators placed 10 in apart, with 12 conductors to the inch, i.e., about 80 for a 12 in-diagonal tube. At the right-hand side, at which the beam has to discharge the array, the tape is bent into a roof-shape. This has been adopted because, in previous experiments, considerable difficulty was experienced with secondary electrons, which cascaded down the array and spread out the wavefront. With the shape now adopted the secondary electrons travel only as far as the next conductor. At the left-hand side, where the electrons have to recharge the array with the aid of a screen grid at ultor potential, the conductors are plane vertical strips.

The arrays produced for the authors had a silver surface (on Nichrome backing), because silver was a metal very suitable for evaporation. Like all pure metals, it is a poor secondary emitter but after a few days exposure to the London atmosphere, silver is coated with a uniform layer of silver sulphide, which is an excellent secondary emitter. Thus, so far, no need for any special surface treatment has been found.

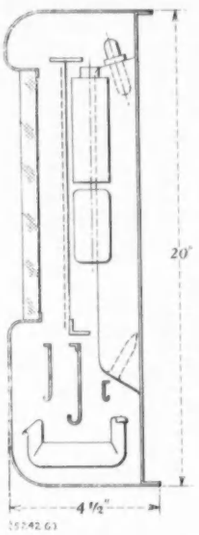
The mask now adopted is a thin sheet, 0·0015 in thick, made of copper or some suitable alloy. This is printed, photographically or by means of rollers, with 40 to 50 parallel strips per inch of an acid-insoluble resist, leaving 20 to 25 per cent of the metal area bare. This sheet is now crimped, i.e., it is folded sharply, so as to form thin parallel ribs, about as high as the strip spacing is wide. The spacing between the ribs can be made wider, even several times wider than the spacing between the strips, without the ribs becoming visible at the distances at which the picture is viewed.

The crimped sheet is also completely coated with resist on the underside, and immersed in an etching solution for a limited time, until the blank spaces between the resist are etched through but not the ribs. Alternatively, this result can be produced without coating the back, by placing the crimped mat on an insulator, and etching it from above electrolytically, with an electrolyte of small throwing power. Finally, the resist is removed with a suitable solvent.

The crimped, etched and washed shadow mask is now stuck on the glass plate serving as envelope, preferably with a cement such as a silicone resin, which remains a little tacky until it is cured, and has sufficient adhesion to hold the mask in position. The coating operation can now follow immediately. The screen is placed in an inclined position in a vertical pipe filled with stagnant air. Above this there is another similar pipe, separated from the first by a horizontal shutter. A measured quantity of phosphor powder of the right colour is injected into the top pipe, and after the air currents caused by the injection have ceased, the shutter is removed. The column of powder now descends almost exactly vertically, with speeds of only a few centimetres per second. As it has only about 0·020 to 0·030 in to fall between the slits and the tacky screen surface, the outlines will be very precise. If the dose is right, there will be no bouncing of the grains, although this is not very critical, since it was found that, at these low speeds, even those grains which fall on other grains instead of the tacky base do not bounce. The process is now repeated for the other colours. It has been found quite easy to remove the loose powder from the shadow mask by means of a powder puff or an electrified conductor. The tacky base solidifies during the baking of the tube.

THE ENVELOPE

In order to exploit fully the advantages of the flat tube, it is highly desirable to give it a plane screen, instead of the usual dished envelopes. It used to be, and perhaps still is, generally believed that it is unprofitable to make the glass so thick that it shall withstand atmospheric pressure without dishing. This is, of course, perfectly true for ordinary glass, but not for toughened plates, which have been suddenly quenched from near the yield point to a temperature well below it. The authors believe that flat tubes made of toughened glass can be so safe that even the safety screen can be dispensed with, replacing it perhaps by a dip into a transparent plastic substance to prevent the splinters from scattering.



The flat tube, which is made of two pressed-glass shells, lends itself very well to a manufacturing process in which all glass-blowing work is avoided, sealing together the two shells with the leads, mostly tapes, between them by means of the excellent enamel glasses now available. But this makes it necessary to grind the two rims flat, with notches for the thicker leads and the exhaust tube, and if in this process one grinds through the compressed skin, the pre-stressed envelope will shatter. Therefore a process was developed in which the flat screen, together with its thickened surround, is fully toughened, while the pre-stressing gradually fades out and reaches a zero value at the time. The best result obtained by the authors is a fourfold increase in strength. If this could be obtained regularly, $\frac{5}{16}$ in plate thickness would be sufficient for a 12 in-diagonal tube, $\frac{1}{2}$ in thickness for a 20 in-diagonal tube, to pass the test at a pressure of 3 atm outside with vacuum inside.

However, especially at the larger screen sizes, which are now the most popular in television, it appears that the flat tube with a metal envelope and an evenly toughened glass window not larger than the screen has decisive advantages over the all-glass tube. Fig. 8 is a cross-section of a metal envelope. The whole electrode system is mounted on the lid, which has the shape of a tray with a network of stiffening ribs outside. This tray fits into the casing, and is argon-arc welded to it along the rim. The tube can be reconditioned by cutting away, say, $\frac{1}{8}$ in of this rim, withdrawing the mount, repairing the faulty parts, and rewelding the rim. Thus the envelope and the electrode system can be used four times until the thickness has been reduced to $4\frac{1}{8}$ in. All leads are arranged at the back, and they project into the set, which is arranged behind the tube, to a depth of about 2 in. All controls are arranged at the sides. The cabinet is reduced to a minimum, i.e., to four plates forming a frame which snugly surrounds the tube. A front cover is unnecessary, and if the tube is given a pleasant finish it looks like a television set.

In Parliament

AIRCRAFT INDUSTRY MERGERS

Integration in the aircraft industry was discussed in the House of Commons last week, arising out of questions by Mr. Roy Mason (Labour). He asked the Minister of Supply to say to what extent the merger of Armstrong Siddeley Motors Limited and Bristol Aero-Engines Limited measured up to his desire for the integration of firms in the industry. Did the Minister anticipate a surplus of skilled labour as a result of these changes and, further, had the Government any plans for using surplus skills of this kind?

It was the Government's policy, Mr. Aubrey Jones said, to encourage the aircraft industry to reshape itself into stronger units. The association between the Bristol Aero-Engine and Armstrong Siddeley companies was an important step in that direction, and he warmly welcomed it accordingly. He hoped that it would lead to an even closer association between the two groups. One purpose of the greater degree of combination which it was hoped would occur in the aircraft industry would be to eliminate redundant capacity with greater ease than would otherwise be possible. So far as the Bristol-Armstrong Siddeley merger was concerned, both firms had been to see him and had explained to him what was proposed. Since it was desirable to reduce the number of management units in the industry, he had welcomed their action.

A MATTER OF SCIENTIFIC PRECISION

Sir Peter Macdonald (Conservative), Mr. Frank Beswick (Labour/Co-operative) and Mr. Mason also asked the Minister of Supply when the House might expect to receive the report of the inquiry into research and development problems in the aircraft industry, which was conducted by the inter-departmental committee set up by Mr. Aubrey Jones a short time ago.

Mr. Jones said that the present military aircraft programme was intended to meet the needs of the Government's defence policy outlined in the White Paper *Report on Defence: Britain's Contribution to Peace and Security* (H.M.S.O., Cmnd. 363, 1*s*.). A report on future policy in regard to aircraft research and development had now been submitted by the working party of officials recently set up and was being considered by the Ministers concerned. He admitted that there was a degree of uncertainty in the industry and it was the purpose of the Government to dissipate that uncertainty as soon as possible.

Pressed further by Mr. Beswick, who urged that the Minister had promised, with some degree of scientific precision, to make a statement before the first day of spring, Mr. Jones retorted that, as he happened to manage a scientific department, scientific precision was the last thing he should ever attempt. There was nothing sinister in the delay in the appearance of his statement.

[The Minister's promised statement was made on Tuesday, 13 May, and is the subject of our leading article this week.]

BLACKBURN N.A.39 AIRCRAFT

Later, Mr. Aubrey Jones told the House that the development of the Blackburn N.A.39 aircraft was proceeding well and that the first of the development batch of that aircraft had made a satisfactory first flight on 30 April. The Blackburn N.A.39 would be used by the Fleet Air Arm as a long-range-striking aircraft.

Mr. Roy Mason asked if the Minister could say whether he could guarantee sufficient orders for the N.A.39 to warrant the complete development of the aircraft, in view of the fact that there appeared to be some doubt whether or not it would be a successor to the Canberra, and even whether it would have any future at all. On these points, Mr. Jones said he was not at all sure what Mr. Mason meant by uncertainty. There was a naval requirement for this aircraft. He imagined that it was information about whether there was a need for it by the Royal Air Force that was wanted. As had been stated by the Air Ministry, the question of a replacement for the Canberra bomber was now under consideration.

In answer to other questions, Mr. Jones stated that he could not say, without previous notice, whether the N.A.39 was subsonic or supersonic, as he would not wish to go beyond security considerations. He told Air-Commodore Sir Arthur Harvey (Conservative) that, as far as export orders for the N.A.39 were concerned, the Government was making every attempt to enlist the interest of other countries within the Western Alliance.

AIRCRAFT EXPORTS ON CREDIT

Steps being taken by the United States to advance the exports of her aircraft were brought to the notice of the House by Sir Wavell Wakefield (Conservative). He pointed out that, during recent years, credits to the amount of 161,245,000 dol had been authorised by the Export-Import Bank of Washington to 11 countries to purchase aircraft and aviation equipment from ten leading American aircraft manufacturers. What credit facilities, he asked the President of the Board of Trade, were being granted by the British Government to these and other countries to enable them to purchase aircraft and equipment made by British aircraft, aircraft engine, and equipment manufacturers?

Mr. J. K. Vaughan-Morgan, the Minister of State to the Board of Trade, replied that he was aware of the activities of the United States Export-Import Bank in the field of aircraft exports. Her Majesty's Government did not normally grant credit facilities, which it was the work of the City and the banks to provide. These institutions were supported by the export credit insurance facilities provided by the Export Credits Guarantee Department. That Department, over the period quoted by Sir Wavell, had guaranteed credits in respect of the export of aircraft, aircraft engine, and aviation equipment to 19 countries to a value of £128 million—a sum equal to no less than 352 million dol.

DECONCENTRATING KRUPPS

The Foreign Secretary was urged by Mr. A. W. J. Lewis (Labour) to make a statement about the Government's intentions regarding the international agreement to dispose of the Krupp armament monopoly. Mr. Ian Harvey, Joint Under-Secretary of State for Foreign Affairs, replied that the Federal Government had communicated a memorandum to the British, French and United States embassies at Bonn, on 25 April, describing the progress that had been made in completing the outstanding deconcentration measures for certain sections of German industries, one of which covered the property of Herr Krupp. That memorandum was now being studied by the three Governments.

As to Press reports that Herr Krupp had said that he did not intend to break up the Krupp monopoly and that he had the active support of the Adenauer Government, many people said things which were reported in the Press and which were not entirely advisable. On the question of the Krupps being allowed to resume the ownership or control of the former Krupp industrial empire, the present British Government had already given assurances to the House on their position in the matter.

DANGERS IN NEW PROCESSES

The attention of the Minister of Labour was called by Mr. S. S. Awbery (Labour) to the fatal effects of the dust of a new plastics compound used in aircraft production, which is harmless until heated and then gives off an invisible toxic acid. Mr. Awbery pointed out that this was one of the hazards arising out of the use of untried and little understood materials, and asked that the number of factory inspectors be increased so that greater supervision and precautions could be provided to cope with the rapid increase in scientific factory developments.

Mr. Iain Macleod stated that the only information he had about this substance having fatal effects was a reference to a fatality abroad about two years ago, which further inquiry had failed to substantiate. There had been no fatalities in this country from that source over the period of several years during which the substance had been used. The manufacturers of the substance issued an advisory leaflet to users.

Protecting Manufacturing Designs

The Parliamentary Secretary to the Board of Trade, Mr. F. J. Erroll, told Mr. Alan Green (Conservative) that the President of the Board believed that some sections of industry are coming to think that changes of one sort or another are desirable in the present provision for the protection of designs used in manufacture. The Government were consulting the various trade and professional organisations concerned. If it became clear that there was a general wish for the law to be reviewed, consideration would be given to the holding of an inquiry.

High Activity in Engineering

Lack of work in the engineering industry was referred to by Mr. Fenner Brockway (Labour). He wanted to know what action was proposed to be taken by the President of the Board of Trade to prevent the growth of unemployment and short time in the engineering industry, which now extended to districts which were previously prosperous, as was evidenced by the trend in Slough. Mr. F. J. Erroll said the answer was "none." Activity continued high in the engineering industry and unemployment in engineering was even lower in Slough than over the country as a whole.

Industrial Resources for Defence

An explanation was asked for by Mr. George Brown (Labour) of the probable effect on British industry of the agreement reached at the recent meeting of the North Atlantic Council to achieve closer co-operation on military research, development and production within the framework of the Western European Union. In reply, Mr. Aubrey Jones, the Minister of Supply, said that he did not foresee any immediate effect. He considered that the recent agreement should eventually lead to a more economical use of industrial resources for defence research, development and production in all the participating countries.

Export of Cold Rolling Mills

Also referred to the President of the Board of Trade was a question by Sir William Robson-Brown (Conservative) as to whether the President would grant licences for the export of small cold rolling mill equipment to Hungary. That country, Sir William pointed out, was prepared to place orders for plant of that kind with Great Britain for prompt delivery and any orders so received would assist employment in the engineering industry in the Manchester area. Mr. J. K. Vaughan-Morgan, Minister of State to the Board of Trade, said that such licences could not be granted so long as the embargo on exports to the Soviet *bloc* continued to apply to this equipment.

Power Station Fumes

The need for precautions to minimise the sulphuric-acid content of smoke emitted by Marchwood power station was referred to by Mr. John M. Howard (Conservative). He also asked if the Government were satisfied that the smoke was harmless to human beings and to property. Sir Ian Horobin, Parliamentary Secretary to the Ministry of Power, said that special precautions, including the use of neutralising substances, were taken in operating the furnaces at this station, to minimise the acid content of the flue gases. Local measurements of the acid concentration there had not revealed any significant increase since the station had begun to operate. He understood that there had been some cases in which near-by property had suffered minor corrosion, mainly of paintwork. There was no evidence of harm to human beings.

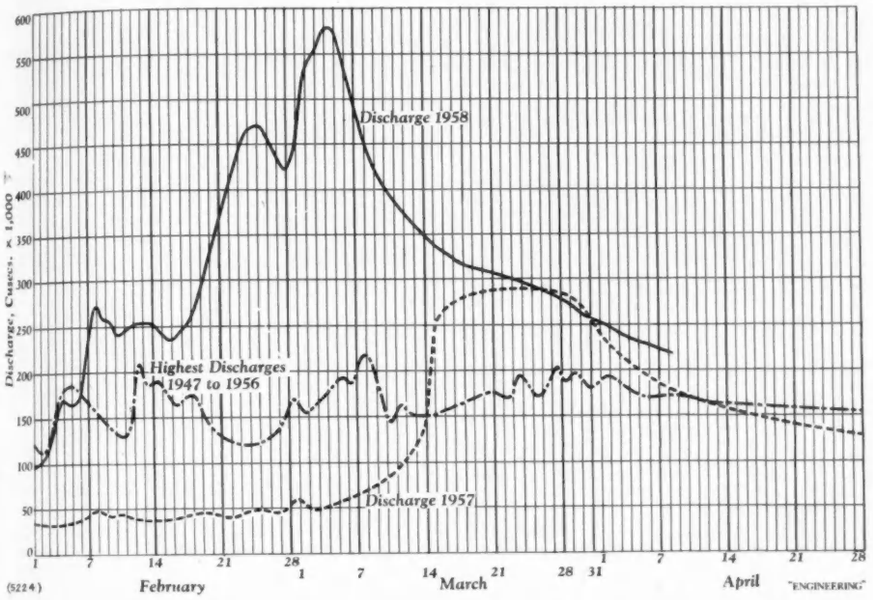
Construction

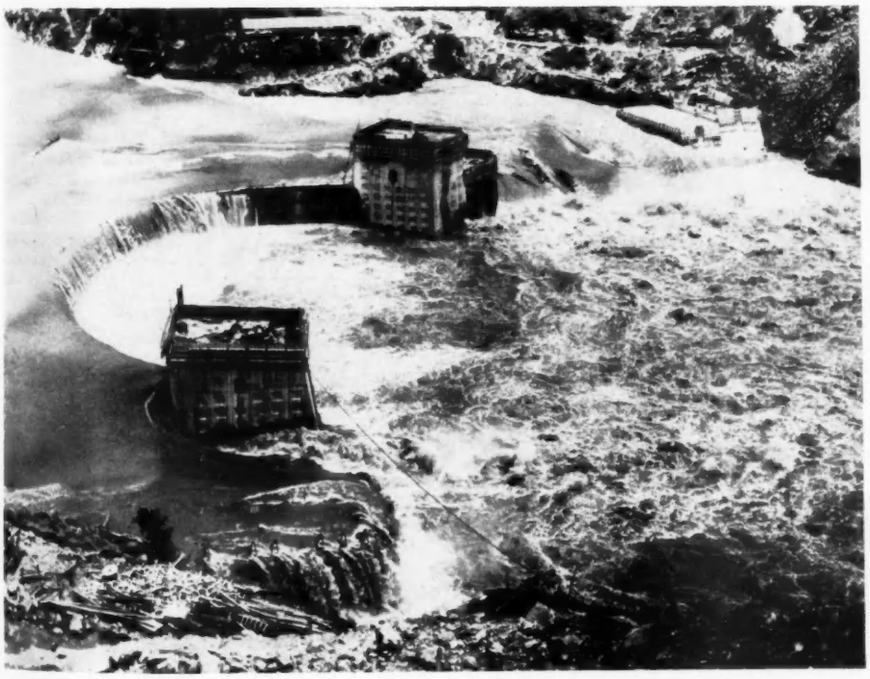
KARIBA DAM ON TIME?

The Federal Power Board and the contractors responsible for building the Kariba Dam have been dogged with bad luck. This is clearly demonstrated by the accompanying chart, comparing the discharge of the Zambesi at the dam site this year and last year with the highest discharges on any day for a given date between 1947 and 1956.

The extraordinary level reached by the water in the early part of March not only flooded the central coffer dam—as can be seen from the photograph below—but also breached it below the water level and carried away the bridges. The extent of the damage to the dam has been ascertained by drilling through the wall and it appears that the hole is approximately 40 ft square; this is considerably less than had originally been thought. Attempts will be made to block this but the actual amount of hold-up to the work on the main dam can be gauged from the fact that the coffer dam only encloses 300 ft of the main dam wall out of a total length of 1,600 ft. On the remainder, pouring has been proceeding at a steady rate. It is expected that by January 1959 the time which has been lost will have been made up and that by March the height of the main dam will be above this year's maximum water level. There has been no delay, however, in the constructional work on the turbine hall.

It has not been possible yet to estimate the additional costs to the project caused by the floods. In any case this figure must be set against any possible savings that may be made on the contract as a whole.





In February of this year the River Zambesi flooded the cofferdam for the Kariba hydro-electric scheme. Just how unlikely the discharge was can be seen from the chart above.

SCOURING ELIMINATED IN YARMOUTH HARBOUR

Serious undermining of the foundations at the entrance to Great Yarmouth Harbour—caused by currents and eddies scouring away the harbour bottom—has made rebuilding of the piers essential. To avoid this happening again after reconstruction, the Hydraulic Research Station, DSIR, has suggested alterations to the design of the new South Pierhead. Experiments on a scale model at Wallingford have shown that a curved pierhead will reduce the eddies and fast currents and thus prevent a re-occurrence. In addition, tests with a radio-controlled model ship indicate that navigation into the harbour will be less difficult.

During the Nineteenth Century, shoaling at the harbour entrance caused a sand bar to form which obstructed navigation. This was overcome in 1872 by extending the North Pierhead to encourage a natural scouring action; this removed the sand bar but the scouring caused deepening of the bed and the pier structures were undermined. In addition, decay and wave action had caused further damage.

The problem was put recently to the Station by Coode and Partners, Westminster, who are consultants to the Great Yarmouth Port and Haven Commissioners. A model of the harbour and adjoining coastline was built to a scale of 1/120 so that existing conditions could be simulated. Tests with a curved South Pierhead showed that the tendency to undermine the structure had been eliminated.

NEW BELFAST WHARF

A new deep-water wharf, 1,241 ft long, providing a depth of 30 ft at O.L.W. and with provision for eventual deepening, by further dredging, to 35 ft, has recently been completed by the Belfast Harbour Commissioners. It is equipped with a single-storey transit shed, 1,100 ft long, with a clear span of 120 ft and a height of 47 ft at ridge level. The wharf is constructed with a flat reinforced concrete slab supported on a piled foundation, the site being on land reclaimed about 75 years ago.

The strata generally consist of about 30 ft of fine estuarine silt, locally termed "'sleetch," overlying 10 to 15 ft of fine red and grey sand, before a bed of stiff red clay is reached. Red sandstone underlies the clay at depths varying from 60 to 92 ft below ground level. Test piles indicated a satisfactory foundation at the northern end of the site, but at the south end pile lengths of up to 90 ft appeared to be required. Experiments made enabled this length to be reduced by forming blisters on the piles, thus increasing the pile size. A pile length of about 56 ft was finally used.

The berth was formed by dredging away the bank after the wharf was built. Trial designs showed that for this condition the cheapest arrangement was one in which the retaining wall was at the front of the wharf. This method largely eliminates the effect of the surcharge behind the wharf, and the width of the deck slab also allowed the ground level to be sloped underneath, thus reducing the height of the retaining wall and allowing the ground immediately behind to be self-draining.

The deck slab, 28 ft wide, is a reinforced concrete flat slab, 2 ft deep, on top of which is a wearing course of average depth of 7 in which houses the crane and tram rails. The weight of reinforcement in the slab and wearing course is 16½ lb per sq. ft. The wharf has two sidings and 16 ft gauge crane rails. There are 15 ton travelling and 6 ton mobile cranes.

The contractors for the wharf were Charles Brand and Son Limited, London, and the transit shed was constructed by Harland and Wolff Limited, Belfast, who also collaborated with the Commissioners' staff in the preparation of details. The new wharf was officially opened by H.M. the Queen Mother on 9 May.

Metals and Materials

THE CHANGING FACE OF STEELMAKING

Considerable effort has been and is being devoted throughout the world to the development of alternatives to the blast furnace for the reduction of iron from iron ore. This has been stimulated by the desire to develop processes that are independent of, or much less dependent on, metallurgical coke or that can utilise materials which, without pre-treatment, are unsuitable for the orthodox blast furnace, or that hold promise for producing an end product containing less impurities than the traditional pig iron.

These comments were made in the course of his presidential address before the Iron and Steel Institute, in London on 7 May, by the newly-inducted President, Mr. C. R. Wheeler, C.B.E., joint managing director of Guest Keen Iron and Steel Company Limited. He added, however, that, in general, it appeared that these alternatives to the blast furnace would have only limited use within the foreseeable future. It was unlikely that there would be any serious rival to the orthodox blast furnace as a mass producer of iron for steel-making.

The electric blast furnace was well established in certain parts of the world and much had been heard of the low-shaft furnace in recent years but its application would appear to be limited. A process for the production of steel without the intervention of an intermediate stage of iron making had long been the goal of steel metallurgists, and it was possible that developments such as the Cyclosteel process of the British Iron and Steel Research Association might have long-term possibilities. Fundamentally, however, such processes would seem to be dependent on a natural or artificial source of pure iron oxide.

At present, there would appear to be no practical alternative, Mr. Wheeler said, to the use of coke in the large-scale production of pig iron. The need to conserve coking-coal resources and to obtain the maximum production of pig iron from the available metallurgical coke might be expected to lead to rapid acceleration in the present trend towards the more extensive use of ore preparation and agglomerating techniques.

The largest and richest sources of iron ore were now generally in regions remote from the main steelmaking areas, and the major steel industries of the world were therefore becoming rapidly more dependent upon imported ore. In the United Kingdom for example, in 1956 home ore accounted for 56·5 per cent by weight of the ore used for iron making. A substantial increase by 1962 had been planned in the tonnage of home ore mined. Even so, however, it was expected that the proportion, by weight, of home ore used in iron making would be little more than 50 per cent.

Home ore was low in iron content; it averaged about half that of imported ore and, in terms of iron content, about 37·5 per cent of our present iron production was based on home ore. It was estimated that the proportion would fall to 33 per cent by 1962.

In terms of iron content, the industry of the United States was already dependent on imported ore for a third of its pig-iron production. In contrast, the U.S.S.R., China, India, and the newly-developing South American industries would appear to have adequate indigenous iron-ore resources for developments which are under consideration.

The growing importance of converter processes, the production of higher proportions of pig iron per ton of steel, the trend towards the use of large electric-arc furnaces for bulk steel production, and the possible introduction of continuous casting suggested a radical change in the fuel balance of future steelworks. At integrated plants based on imported ore, large quantities of coke-oven and blast-furnace gas would be available, while converter and electric steel-making processes would not require gas or oil fuel. A greater proportion of electricity would be generated which might be used economically by electric-arc furnaces. The British steel industry was based so predominantly on the open-hearth process, however, that the introduction of other steelmaking methods would only have a gradual effect on the national position.

NON-FERROUS METALLURGY 1908-1958

The growth of the metal industry in the last half century is indicated by the figures given in the Table for the world smelter production of the common non-ferrous metals in 1907 and 1957.

Metal	1907	1957
	Long tons	Long tons
Aluminium	17,000	3,306,000
Copper	709,671	3,412,000
Lead	981,100	2,405,000
Nickel	16,024	145,000
Tin	104,549	268,000
Zinc	726,750	2,907,000

These figures were quoted by Professor R. S. Hutton in the course of his Golden Jubilee Lecture, delivered in London on 28 April, on the opening day of the 50th anniversary celebrations of the foundation of the Institute of Metals. The lecture was entitled " The Institute of Metals: Some Recollections and Reflections," and Dr. Hutton, who is an original member and Emeritus Goldsmiths' Professor of Metallurgy, University of Cambridge, discussed some milestones in the history of the Institute and of non-ferrous metallurgy, from the inaugural meeting of the Institute, held in London on 16 June, 1908, down to the present day.

Continuing his survey of the industry over fifty years he added that the large increase in production had resulted from new sources of supply, for example, Australian lead and zinc, the Congo-Rhodesian copper belt, bauxite from Ghana and Jamaica for aluminium, and the great expansion of the Sudbury nickel field in Canada. The froth-flotation treatment of ores had rendered available much poorer and more complex ores than were workable in earlier times. The flotation process, which dated from 1905, now treated at least 1,000,000 tons of poor metallic ores every day.

Many of the common metals were now supplied, in tonnage quantities, of a purity quite undreamt of at the beginning of the century. With such purity, the working properties of many of these metals and their alloys had been greatly improved, and this had led to entirely new applications.

At present, outputs of several of the " newer " metals surpassed the 1908 production of either nickel or aluminium, as indicated by the following very approximate figures (in long tons per annum): chromium, 80,000; cobalt, 14,000; molybdenum, 28,000; magnesium, 140,000; titanium, 15,000; uranium, 16,000; tungsten, 30,000; cadmium, 8,495; and manganese upwards of 7,000. Again, metals which, in 1908, were almost confined to museum specimens were also rapidly becoming available in commercial quantity, namely, zirconium, beryllium, lithium, niobium, and silicon.

It was surprising to find how recent were many of the best-known metals and alloys. For instance, stainless steel had been discovered by Harry Brearley only in 1912, ductile tungsten for electric lamps by W. D. Coolidge in 1909, and chromium plating by G. J. Sargent in 1920. Duralumin was first produced by Alfred Wilm in 1909, and taken up by Vickers with the help of H. B. Weeks and Horace Clarke, both members of the Institute. Moreover, it need only be added that the first Derby Rolls-Royce motor car dated from 1908, and the first all-metal aeroplane from 1920, to realise the progress made within the lifetime of the Institute.

For centuries nearly all the metals and alloys dealt with by the Institute were melted in crucibles in coke-fired " pot-hole " furnaces. Shortly before the Institute was founded, attempts were being made to find improvements, and both in industry and at the Royal Mint gas-heated furnaces were being tried out. Furthermore, as a result of research work in the United States, the Ajax-Wyatt low-frequency and the Northrup high-frequency electric melting furnaces had been produced, and from 1916 onwards these were rapidly adopted throughout the world. They had added greatly to the efficiency, cleanliness, and comfort of countless casting shops.

SINTERED-METAL FRICTION MATERIALS

In order to include the manufacture of sintered metal facings for clutch and brake designs and to produce also Cerametallic friction materials, Ferodo Limited have recently installed full-scale plant at their works at Chapel-en-le-Frith, Derbyshire, with the collaboration of the S.K. Wellman Company of America, which firm has specialised in the application of sintered metals to the brake and clutch lining industry. The materials are to be used for the control and transmission of power such, for example, as heavy-duty master, steering and other clutches in road vehicles, excavators, cranes, earth-moving machinery, tractors and agricultural machines.

Until now conventional friction materials, based on asbestos, have fulfilled all the demands made upon them and while the new sintered metals will not replace asbestos-based products, they will make possible the design of clutches capable of sustaining duties beyond the scope of conventional linings and facings. They will also provide for replacement linings and facings on heavy equipment, mainly of American design, which have standardised metallic facings for certain brake and clutch applications.

The sintered metal facings are flat discs or segments generally built on to steel backing or core members and may be very thin by traditional standards. The complete units may then be mounted by riveting, or more frequently, the core member may be gear-cut or splined to transmit torque. After sintering, the assemblies are finished by grinding, edge trimming, drilling and branding. They are supplied for dry operation or for oil-immersed conditions and give excellent service against normally accepted steel or alloy mating members. Because a material produced from a metal powder absorbs energy and conducts heat faster than most organic or mineral friction materials, it can be utilised under conditions which would lead to excessive temperatures for asbestos-based materials.

Of the six Ferodo sintered materials available,

Design

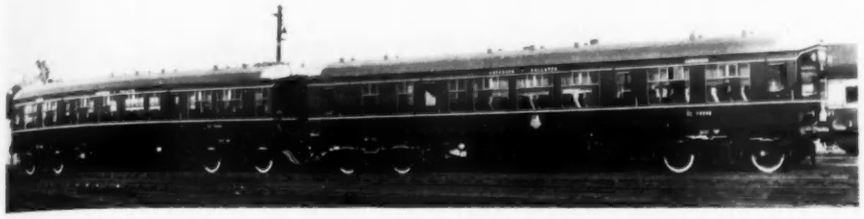
BATTERY RAILCARS FOR BRANCH LINE

The introduction of battery railcars on the Aberdeen-Ballater branch of British Railways is the most recent attempt to use this form of traction. It is hoped that it will be a solution to the ever-present difficulties of maintaining a service on lightly used branch lines. The unit will be the first battery railcar to go into service in Britain, but similar units are in regular operation in Germany. The Aberdeen-Ballater line was chosen as affording the best testing ground. It is 43½ miles long with 12 intermediate stops and a maximum gradient of 1 in 68. The batteries will be charged at Aberdeen and then again at Ballater. The maximum permissible speed of the train is 60 m.p.h. and the acceleration is 0·75 m.p.h. per sec. up to 30 m.p.h.

The unit consists of two coaches of the type used in light-weight diesel stock, modified to accommodate the batteries. Two motors are fitted to a bogie of one vehicle and can be controlled from the driving compartments at either end. The battery, which consists of 216 lead-acid cells supplied by Chloride Batteries Limited, is disposed in two units of 8 tons each under the two coaches. The cells are connected to give a nominal voltage of 440 with a storage capacity of 1,070 Ah. The batteries are in cradles which can be partially withdrawn for inspection.

The traction control equipment was supplied by Siemens-Schuckert (Great Britain) Limited and is the same as is being used in the German cars. Control is effected by series/parallel arrangements together with three stages of field weakening, and with facilities for cutting out either motor. The contactors are cam operated by an electric motor whose speed is regulated by the traction motor current, giving very smooth and automatic acceleration. The driver's controls are therefore very simple. The two motors, made by Siemens-Schuckert (Germany) are each rated at 100 kW, are nose-suspended, and drive through single-reduction spur gearing with a ratio of 81 to 13. An auxiliary air compressor supplies air for the brakes, horn, etc., and lighting is from a motor-generator set mounted below the motor coach. Oil heating is used.

Battery charging is carried out at the terminal stations using Bruce Peebles equipment designed to charge at a high rate so that the operation can be completed in the time the train is at the station. The electrical circuits are interlocked so that the charging cables cannot be connected or disconnected while they are alive, nor can the train be moved while the cables are connected. Interlocked cooling fans are installed to control the temperature of the batteries during charging.



Battery railcars may help to solve the branch line problem.

SM1 to SM6, five are bronze-based and the remaining one (SM4) iron-based. This is used as a lining to protect costly parts, such as flywheels and pressure plates from heat damage and wear.

The Cerametallic friction materials produced by the firm are broadly similar to the sintered metal products, except that, as the name implies, they contain a proportion of ceramic powder which increases their heat and wear resistance and raises their friction level. These advantages, it is stated, are to some extent offset by a tendency to abrasiveness and higher cost, due to manipulating difficulties inherent in the material. In consequence, the Cerametallic friction material is formed into a circular pad or button in a steel cup and a number of such buttons can be riveted on to the surface of a supporting member. The principal applications for components of this type are for the clutches of earth-moving machinery and agricultural machinery and the disc-brake pads of aircraft.

TRYING OUT TITANIUM

Because titanium is new to many industries where its properties might offer considerable advantages, William Jessop and Sons Limited have decided to offer development supplies of "Hylite" alloy on specially attractive terms, to enable engineers and designers to carry out trials on new projects and products.

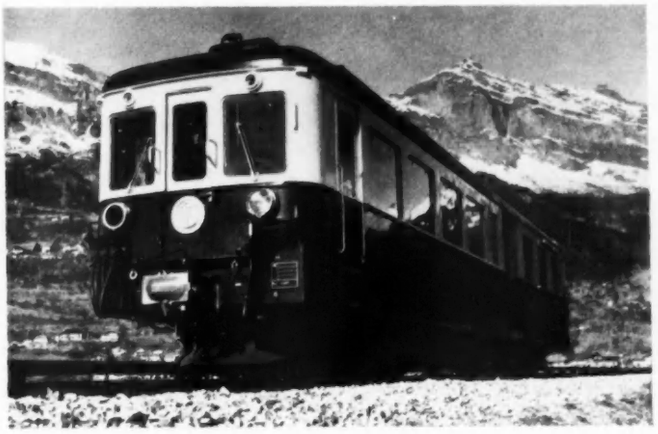
To meet new demands for titanium, Jessop's are installing new plant at their Brightside Works, Sheffield, 9, including a consumable-electrode vacuum arc furnace, which will enable them to produce ingots up to 24 in diameter and 3 tons in weight. Meanwhile, even before the new equipment is commissioned, Jessop's can offer titanium and its alloys in many different forms. "Hylite" alloys can be supplied in billets, forgings, drop stampings, bar, rod and wire. In certain grades the material is available as sheet, strip, tube and extruded sections.

Not so long ago titanium was little more than a curiosity, though its existence was known as far back as 1790. It is only in recent years that processes have been developed for extracting titanium from the ores and working it on a commercial scale. The metal is firmly established in aircraft manufacture, but it has potential uses in many different fields, where its high strength-to-weight ratio and its corrosion resistance give it advantages over other metals.

ELECTRIC TRAIN SETS FOR STEEP GRADIENTS

French Railways are putting into service four new train sets on the St. Gervais-Chamonix-Vallorcine line, which has the steepest gradient in Europe to be operated by adhesion alone.

The sets will consist of two motor cars with a trailer between; one of the motor coaches is shown in the illustration. The coach weighs 38 metric tons and has a continuous rating of 545 h.p. Current is drawn from an outside third rail at 800 volts d.c. The make-up of the sets can be varied to suit the seasonal traffic and provision is made for such extras as ski racks for use in the winter season. A three-car set will accommodate in summer 143 seated and 101 standing passengers, figures that are reduced to 136 and 93 in winter.



New train sets are being introduced on the Chamonix valley line, which has a maximum gradient of 9 in 100.

GOVERNING DIESELS

A brief insight into the problems of governing diesel engines was given by Mr. R. A. Fuller in a paper presented to the Diesel Engineers and Users Association on 20 March. The title was "Governing of Diesel Engines" and it included mention of most of the types of control in present use.

The earliest and simplest is the flyweight system that dates back to the time of Watt, and is still in use. Commercial models can detect speed changes of the order of 1 in 2,000, and laboratory types have been made sensitive to 1 in 10,000. However, there is an inherent time delay before correction can take place which can easily be as much as 130 milliseconds. The introduction of a hydraulic servo adds another delay of about 25 milliseconds. Since the acceleration rate of the crankshaft can be between 500 and 5,000 r.p.m. per sec. for a free engine, this delay can be serious.

A different approach to the problem is based on the governor measuring the load and not the speed, in other words, governing through the first, and not the second, variable. If there is no delay such a governor will correct the rack setting before any speed change occurs. It has been achieved for diesel alternator sets by using two simple electrical circuits, one of which gives a signal proportional to the alternator load and the other one proportional to the speed error. These two are combined and amplified to produce a signal of the correct power level for effective use. For mechanical considerations a magnetic amplifier is used, the output of which is fed to the engine at the fuel bar actuator. Thus the first action is to reset the rack to correspond to any change in load and then to make any small speed correction needed due to inaccuracy and delay in the first re-setting.

Continuing **Design**

NUCLEAR REACTOR FOR DISTILLING SEA-WATER

Making the Most of Fissile Fuels by Operating at Low Temperature and High Load Factor

By Isaac Vilentchuk, M.E., *and Nathan Arad*, M.SC., A.M.A.S.M.E.
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Owing to present limitations in the design and construction of nuclear reactors, they can only be operated economically in certain situations and for certain purposes. It is on the discovery of these conditions and applications, as much as on technical development, that the initial exploitation of nuclear energy depends. The authors of this article suggest that sea-water demineralisation is a field in which nuclear reactors can be usefully employed, pointing out that low operating temperatures are sufficient and that operation may be virtually continuous. Where fresh water is scarce and sea-water abundant, as for example in Israel, it is clear that a low temperature reactor could be operated profitably. A power reactor requires dry steam in the secondary circuit so that high temperatures in the primary circuit are essential; but where the requirement is for process heat, the conditions are not so onerous. In addition the pressure in the low temperature reactor vessel need not be high, since at the temperatures called for boiling is inhibited at a comparatively low pressure.

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Summary

The object of the present article is to show that a pressurised-water nuclear reactor producing low temperature steam for distillation of sea-water for irrigation, domestic and industrial usage, will operate in highly favourable conditions with a steady load during practically 8,760 hours per year. It is maintained that the constructional and technological features of a pressurised-water reactor used for generating low temperature steam will be much simpler than for one working in conjunction with an electric power plant. Moreover, certain nuclear features of the Low Temperature Reactor (LTR) may be favourably compared with those of the Shippingport type reactor. By analysing cost components of heat generated by an atomic power plant and those of a Low Temperature Reactor working in conjunction with a sea-water demineralisation plant, the total cost of distilling water is obtained.

The greatest effort of engineering thought is directed towards the use of heat extracted from nuclear reactors for the generation of electricity. In order to achieve high thermal efficiency of the power generation cycle, the pressure and temperature of the steam must be maintained as high as possible. This, however, creates very difficult engineering problems which have not yet been successfully solved in the "conventional" reactors using water (light or heavy) or compressed gas as a coolant medium. The use of thermal reactors for generation of low temperature (and low pressure) process steam was considered not practical owing to the difficulty of ensuring steady consumption of this steam. In general practice the required quantities of process steam cannot justify the construction of large reactors. Atomic power stations are connected to a country-wide grid and take over the base load. A nuclear reactor for generation of process steam will not have generally such favourable conditions of operation and will be subject to fluctuations of steam consumption.

A nuclear reactor producing low temperature steam for distillation of sea-water for drinking and irrigation purposes, especially in arid and semi-arid countries, with the possibility of storing fresh water during reduced consumption, may have highly favourable conditions of operation. A "Low Temperature Reactor" (LTR), working in conjunction with an evaporation still, may have, under such conditions, a load factor equal to the availability factor which in this case may be taken as 95 per cent.

Steam for a flash type evaporation still usually has an inlet pressure between 10 and 15 lb per sq. in abs and corresponding inlet temperature between 193° F. and 213° F. The specified quantity of seawater demineralised per unit of low-pressure steam fed to the evaporator varies considerably from one manufacturer to another. The figure of 6 lb of fresh water per lb of steam is considered safe. Safe future development may be expected to reach 8 to 9 lb of water per lb of steam.

Features of the Low Temperature Reactor

The technological and constructional features of a pressurised-water reactor (PWR) will be modified when the plant is used for generation of low temperature steam. The important feature of PWR is that high-purity light water serves as both coolant and moderator operating under high pressure (2,000 lb per sq. in in the Shippingport Reactor).

TABLE I *Comparative Data for the Shippingport Reactor and the LTR.*

Item	Unit	Shippingport Reactor (power)[1]	LTR (demineral)
Reactor heat output	B.t.u. per hour	790×10^6	790×10^6
Steam pressure ..	lb per sq. in abs.	600	15
Generator (heat exchanger) outlet steam temp. (t_2)	°F.	486·3	213
Steam generator feedwater temperature (t_1)	°F.	325	213
Temperature rise in steam generator ($t_2 - t_1$)	°F.	161·3	0
Enthalpy rise ($h_2 - h_1$)	B.t.u. per lb.	906·2	870·3
Steam generated ..	lb per hour	870×10^3	815×10^3
Overall fuel enrichment	per cent uranium 235	1·1	1·1
Coolant:			
(*a*) Substance ..	—	Light water	Light water
(*b*) Primary outlet temperature (t_4)	°F.	542	268·7
(*c*) Primary inlet temperature (t_5)	°F.	508	234·7
(*d*) Temperature rise in the core	°F.	34	34
(*e*) Temperature difference at heat exchanger coolant entrance ($t_4 - t_2$)	°F.	55·7	55·7
Primary circuit operating pressure (pressure vessel)	lb per sq. in abs.	980	41
Design vessel pressure	lb per sq. in abs.	2,500	100

Temperature differences in the LTR will correspond to those of the Shippingport Reactor. The primary coolant temperature, which is 273° F lower than in the PWR, will greatly affect the pressure vessel—the design pressure of the LTR vessel will be 25 times lower than that of the Shippingport Reactor.

The Shippingport Reactor vessel has an overall height of 33 ft, with a welded cylindrical section of about 7 ft, and a nominal wall thickness of 8½ in. The hemispherical closure is forged and has final thickness of approximately 10 in, with an adequate reinforcement for the control rods and fuel tubes.[2]

The pressure-vessel design code requires consideration for stresses due to pressure, mechanical loading, and thermal gradients. A PWR vessel working in conjunction with a power plant is particularly susceptible to thermal stresses due to load variations.[3] The neutrons and gamma rays evolved produce in the walls of a reactor vessel an additional thermal gradient. The LTR, however, working in conjunction with a sea-water evaporation still, being steadily loaded and having thinner walls, will be subjected to lower thermal stresses since these decrease with wall thickness.

The LTR lower coolant temperature will favourably affect the corrosion rate of the vessel and piping, as the corrosion increases exponentially with temperature. To resist corrosion under the prevailing temperatures in the Shippingport Reactor, the vessel has a 0·25 in stainless-steel inside cladding tightly bound to the carbon steel plates. The stainless steel protecting cladding may become superfluous in the construction of the LTR.[4, 5]

One of the main components of the PWR is the "pressuriser," which regulates the system pressure during load variations. Under any load variations within the prescribed limits the phase of the coolant must not change. The LTR will enjoy a steady state of operation without any abrupt changes, thus no changes of temperature and pressure of the coolant may be anticipated. A simpler pressuriser may be envisaged for the LTR, the major function of which will be reduced to that of a relief valve.

Many other primary system components will be either simplified or reduced in size. With considerably reduced danger of leakage, as a result of low pressure, the construction of pumps, especially those for main coolant, will be greatly simplified. The same may be said about the main stop valve, steam generator, piping system, and the hydraulic and steam apparatus. There will be no need for any steam separators.

To restrict the spread of radioactivity in the event of casualty, the nuclear part of the Shippingport plant is completely enclosed with steel containers. The design pressure of these containers is slightly over 50 lb per sq. in, and their total gross volume is 600,000 cu. ft. It may be expected that for the LTR steel containers will become unnecessary. It is stated that 2,500 lb per sq. in abs represents about the highest practical pressure with present-day technology. This may be compared with the 100 lb per sq. in design pressure that is required for the LTR vessel.

Details of Nuclear Behaviour (preliminary calculations)

It is assumed that in steady state operation of a PWR the fuel-element surface temperature will be the same as, or very close to, that of the coolant water. The heating-element surface temperature in the Shippingport Reactor is 88° F higher than the coolant exit temperature. It is suggested that the LTR core should have about the same size and geometry as in the Shippingport Reactor.

The approximate evaluation of the neutron flux in the LTR is based on the following argument. When the neutrons are in thermal equilibrium with the moderator's atoms they will be subjected to a Maxwellian distribution of velocity. The most probable velocity v_0 corresponds to the kinetic energy $k\,T$, where k is the Boltzmann's constant ($= 1{\cdot}380 \times 10^{-16}$ erg per degree C) and T, the temperature of the distribution on the Kelvin scale.[6] Thus

$$\tfrac{1}{2} m v_0^2 = k\,T \quad . \quad . \quad (1)$$

$$v_0 = \sqrt{\frac{2\,k\,T}{m}} \text{ cm per sec} = 1{\cdot}28 \times 10^4 \sqrt{T} \text{ cm per sec.}$$

The average neutron velocity $\bar{v}$ of the Maxwell distribution is greater than the most probable velocity v_0 by the factor $2\sqrt{\pi}\,(= 1{\cdot}128)$, so

$$\bar{v} = 1{\cdot}44 \times 10^4 \sqrt{T} \text{ cm per sec.} \quad (2)$$

The average thermal neutron flux (ϕ) in the Shippingport Reactor is about $5{\cdot}9 \times 10^{13}$ per sq. cm per sec.[2]

The thermal neutron density $\bar{n}$ at the average velocity can be evaluated from the equation

$$\phi = n v \quad . \quad . \quad . \quad (3)$$

TABLE II *Thermal Neutron Velocity*

Item	Unit	Shipping-port Reactor	LTR
Element surface temperature	Degrees Kelvin	605·2	453·4
Most probable velocity (v_0)	Cm per sec	$3{\cdot}159 \times 10^5$	$2{\cdot}725 \times 10^5$
Average velocity ($\bar{v}$) ..	Cm per sec	$3{\cdot}552 \times 10^5$	$3{\cdot}066 \times 10^5$

TABLE III *Thermal Neutron Flux (Tabulation)*

T (deg K)	$v_0 \times 10^{-5}$ (cm per sec)	$\bar{v} \times 10^{-5}$ (cm per sec)	$\bar{n} \times 10^{-8}$ (cm^{-3})	$\phi \times 10^{-13}$ (cm^{-2} sec^{-1})	Reactor
605·2	3·159	3·552	1·661	5·9	Shipping-port
580	3·092	3·477	1·628	5·66	
560	3·038	3·417	1·603	5·48	
540	2·984	3·355	1·577	5·29	
520	2·928	3·293	1·551	5·12	
500·5	2·872	3·230	1·524	4·92	
475	2·798	3·147	1·489	4·69	
453·4	2·734	3·074	1·458	4·48	LTR

The thermal neutron density in the Shippingport reactor:

$$\bar{n} = 1{\cdot}661 \times 10^6 \text{ per cu. cm.}$$

The thermal neutron density and the average neutron flux in the LTR can be (approximately) evaluated from the Maxwell distribution of velocity equation

$$d\,n = \frac{4\,n}{v_0^3 \sqrt{\pi}} v^2 e^{-\frac{v^2}{v_0^2}} d\,v \quad . \quad (4)$$

(a) Burn-Up

The " burn-up " is defined as the proportion of the total fuel in the reactor (including any fertile material that may be present) that is consumed in a given time and under given thermal neutron flux. Thus, we have[7]

$$B = E\,(1 - e^{-\sigma \phi t}) \quad . \quad . \quad (5)$$

where B is the burn-up of uranium atoms (per cent), E is the uranium 235 enrichment (per cent), σ is the thermal neutron cross-section of uranium 235 (cm^{-2}) (assumed constant), ϕ is the thermal neutron flux (cm^{-2} sec^{-1}), and t is the irradiation time in seconds.

The depletion of the uranium 235 is considered to be influenced by fission only. The overall fuel enrichment in the Shippingport and in the LTR is 1·1 per cent.

Let suffixes (1) and (2) relate to the Shippingport Reactor and the LTR, respectively. Letting $B_1 = B_2$, $E_1 = E_2$, and assuming σ = constant we get

$$\phi_1 t_1 = \phi_2 t_2 \quad . \quad . \quad . \quad (6)$$

$$\frac{t_2}{t_1} = \frac{5{\cdot}9}{4{\cdot}48} = 1{\cdot}317 \text{ (refer to Table III).}$$

Under equal conditions, the heating element in the LTR will last about 32 per cent longer than in the Shippingport Reactor. This prolonged life will have an important bearing on the fuel economy of the LTR.

(b) Power Output

The fission cross-sections of uranium 235 at low neutron energies range, vary in accordance with the " $1/v$ law," that is, the fission cross-section will inversely decrease with thermal neutron velocity. Consequently, the fission cross-section in the LTR will be higher than in the Shippingport Reactor[8].

The reactor power output P in kW may be expressed

$$P = 8{\cdot}3 \times 10^7\, g\, \sigma_f\, \phi \text{ kW} \quad . \quad (7)$$

where g is the mass of fissile material in gm., σ_f is the fission cross-section, and ϕ is the neutron flux.

According to the $1/v$ law, we get

$$\frac{\sigma_{f1}}{\sigma_{f2}} = \frac{3{\cdot}074}{3{\cdot}552} \text{ (refer to Table III)}$$

$$\sigma_{f2} = 1{\cdot}15\, \sigma_{f1}$$

In order to get equal power output from both reactors we set $P_1 = P_2$:

$$8{\cdot}3 \times 10^7 g_1 \sigma_{f1}\, \phi_1 = 8{\cdot}3 \times 10^7 g_2 \sigma_{f2} \phi_2$$

$$g_2 = 1{\cdot}145\, g_1$$

thus, the fuel inventory of the LTR must be by 14·5 per cent greater.

(c) Reactivity

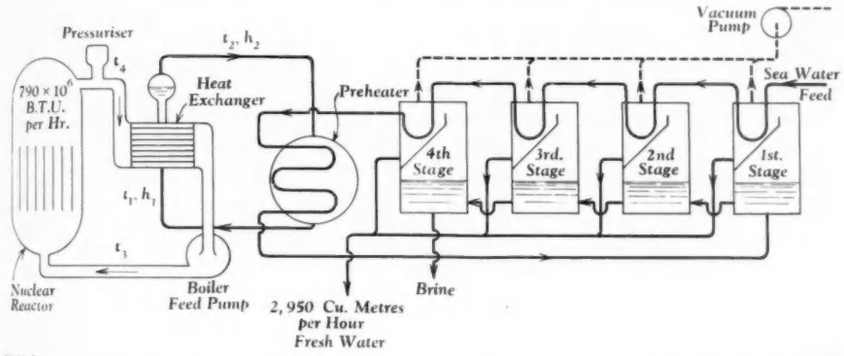
With the decrease of temperature the reactivity of the core will increase. The increased reactivity will adversely affect the nuclear stability of the reactor, thus requiring more attention to the control system. However, this consideration is of major importance only in connection with transient changes of the power level. The LTR working in conjunction with an evaporation still, as already mentioned above, will have a steady power level, practically without fluctuations.

(d) Xenon Poisoning

Xenon 135 is the most important fission-product poison. During the steady work of the reactor an equilibrium xenon 135 poisoning is created. An excess of reactivity is required in order to compensate the effect of this (as well as other) poisoning. The xenon poisoning increases with thermal neutron flux. In the LTR the equilibrium xenon poisoning will be lower than in the Shippingport Reactor.

(e) Conclusion

Certain nuclear features of the LTR were shown to compare favourably with those of the Shippingport Reactor.



Low temperature reactor (LTR) for sea-water demineralisation. A reactor of this kind using light water as coolant and moderator will operate at a pressure which is a fraction that in a conventional power-producing pressurised-water reactor (PWR).

Economy of Sea-Water Distillation

There is little experience in the construction and operation of large evaporation stills. The largest sea-water demineralisation plant, using exhaust steam from a 12,500 kW turbine, is now being erected in Aruba, Antile Islands. The plant will supply about 10,000 cu. metres per day of distilled water, using six-effect evaporators. Although multiple-effect evaporators for sea-water demineralisation are extensively used on board ships, their size and heat economy are in no way suitable for large-scale water supply. Recent research in problems of drop-wise condensation, thin turbulent liquid films, and the optimum velocities of the interacting agents (steam and sea-water) as well as the development in multi-stage flash-type evaporators will undoubtedly considerably increase the distillate to steam ratio in the evaporating stills.

The Saline Water Conversion Report, 1955, is quoted: " Research investigations to date have demonstrated that heat transfer rates as high as five to seven times that attained in present-day evaporators are readily maintained."[9]

In distillation of sea-water an important item of expense is the cost of steam, that is, the cost of fuel per unit of demineralised water. Since for distillation low-pressure steam (around 15 lb per sq. in abs) is used, the process may be economically performed using exhaust steam from steam turbines working against back pressure instead of vacuum otherwise created in the condenser.

A question may be put forward: under what conditions will it be advisable to use a LTR, generating low-pressure steam for the single

TABLE IV *Distillate to Steam Ratio*

Producer	Daily supply, cu. metres per day	Distillate to steam ratio	—
Continental firm	50,000	4·65	Project, using steam from a 100,000 kW power station. (Private communication)
G. and J. Weir	8,000 to 10,000	4·88	Aruba, Antile Islands, using exhaust steam from 12,500 kW power station
The Griscom Russel Co., U.S.A.	18,500	6·0	Project J. Leicester, *British Chemical Engineering*, Aug., 1956
W. L. Badger ..	65,000	20·0	Project Saline Water Conversion, 1955, Annual Report
Safe future development	50 000 to 100,000	8	

Continuing **Design**

purpose of distillation of sea-water, as compared with a dual-purpose PWR (Shippingport type) generating electricity and using exhaust steam for distillation?

It can be shown that the generating capacity of the Shippingport Reactor working on a dual purpose 15 lb per sq. in abs extraction turbine will be reduced from 71,400 kW to 55,000 kW. The quantity of steam which will be directed in this case to the evaporator will be 600×10^3 lb per hour. With safe rating of the evaporation still, the Shippingport Reactor will distil 2,170 cu. metres per hour as against the 2,950 cu. metres per hour of the LTR. Taking into account 75 per cent load factor of the power plant, the yearly production of distillate will be $14{\cdot}25 \times 10^6$ cu. metres, as compared with $24{\cdot}55 \times 10^6$ cu. metres from the LTR. It is assumed that the LTR evaporation still will operate 8,300 hours per year (95 per cent load factor).

The single-purpose LTR will suit for localities where the requirements for sweet water are larger than the amount which can be supplied by using exhaust steam from power plants, that is, in arid regions situated on the sea shore or in its proximity, where the requirements for electric energy or the cost of fuel do not warrant the erection of suitable power plants. This applies especially to industrially underdeveloped countries. The following may serve as an example: the irrigation of 1 acre in an arid zone requires 3,000 cu. metres of water per annum. An efficient evaporation still will require the exhaust steam of a 1 kW turbine to produce about 380 cu. metres of distilled water per annum working with 95 per cent load factor. For the irrigation with distilled sea-water of a tract of land of say 75,000 acres, exhaust steam from a 600,000 kW capacity power plant will be required. This tract of land is sufficient for 8,000 to 9,000 smallholding farms with an agricultural population of only 40,000 to 50,000. A power plant of such capacity will certainly be out of the question.

The following basic data were taken for the comparative cost evaluation of a dual-purpose atomic plant (generation of electricity and distillation of sea-water) and a single-purpose atomic plant (distillation of sea-water only). There are no data available for the Shippingport pressurised-water reactor. We shall use the average figures given last year by Sir Christopher Hinton, relating to an atomic power plant of 150 MW capacity.[10] It should be noted that the load factor of atomic power plants is likely to decrease as their share in carrying the grid load increases.

TABLE V *Cost of Electricity Generated by an Atomic Power Plant*

1(*a*) Capital charges, nuclear portion	2·85*	
1(*b*) Capital charges, electric generation portion	1·50	0·00435 dol per kWh
2. Fuel inventory		0·00070 dol per kWh
3. Fuel replacement		0·00280 dol per kWh
4. Operation and maintenance		0·00070 dol per kWh
		0·00855 dol per kWh

* Division of capital charges taken from other sources.

Load factor 75 per cent, grid price 0·0070 dol per kWh. No residue value of the fuel element. No credit for plutonium. Investment in the plant (nuclear and electric generation portions), 350 dol per kW.

The investment in the nuclear portion (including steam generation) of the LTR per kW (heat) will be considerably lower than that in a PWR. For a reactor of 500 MW (heat) capacity the investment of 30 dol per kW (heat) is considered sufficient. Although the LTR dealt with in this paper is of a smaller size—about 225 MW (heat)—we are using, for sake of comparison, the above figure of 30 dol per kW (heat). The conclusions arrived at will be also adaptable to larger reactors.[11]

As has been shown, the LTR will require a 14·5 per cent increase of fuel inventory, and the life-time of its fuel elements will increase by 32 per cent as compared with the Shippingport Reactor. The operation and maintenance of the LTR (distillation only) will be also reduced.

The overall thermal efficiency of the Shippingport power cycle is 30·1 per cent. Recalculating Table V per kWh (heat) generated in the steam generator, and making the necessary adjustments for the LTR working with a 95 per cent load factor, we arrive at the figures in Table VI.

TABLE VI *Comparing Cost of Steam Heat Generated, mills per kWh (heat)*

—	PWR	LTR	
	75 per cent l.f.	75 per cent load factor	95 per cent load factor
1. Capital charges (nuclear portion)	0·858	0·37	0·29
2. Fuel inventory	0·210	0·24	0·19
3. Fuel replacement	0·840	0·57	0·45
4. Operation and maintenance	0·210	0·12	0·10
Total	2·118	1·30	1·03

The decreased income from the Shippingport Reactor working on dual purpose may be calculated as follows:—

Decreased generation per year: $(71{,}400 - 55{,}000) \times 8{,}760 \times 0{\cdot}75 = 108 \times 10^6$ kWh.

Decreased income per year: $108 \times 10^6 \times 0{\cdot}00855 = 928{,}000$ dol.

This decreased income is a direct result of the reactor demineralising $14{\cdot}25 \times 10^6$ cu. metres of sea-water per annum. The cost (not including the distillation portion) per cu. metre of distillate will be: $(928{,}000 \div 14{\cdot}25) \times 10^6 = 65{\cdot}2$ mills per cu. metre.

Heat required in the LTR per lb of steam (Table I) will be: $\frac{790 \times 10^6}{815 \times 10^5} = 970$ B.t.u. per lb which is equal to 78·3 kWh (heat) per cu. metre of distillate.

According to Table VI, the LTR steam heat cost per cu. metre of distillate will be: $1{\cdot}03 \times 78{\cdot}3 = 80{\cdot}6$ mills.

Various sources indicate that the investment in a distillation plant per cu. metre-year, is roughly 1 dol, depending upon size and capacity. Thus, the capital charges for the distillation portion are found to be about 80 mills per cu. metre.

The total cost of distilling water, including capital charges, labour and maintenance, will be:

Shippingport Reactor 175 mills per cu. metre
LTR .. .. .. 170 mills per cu. metre.

The only practical and economical solution of sea-water conversion is an integrated power generation-sea-water distillation plant.

From the above it can be seen, however, that distillation of sea-water on a large scale can be achieved at a similar cost (as a matter of fact at even lower cost) by using heat generated by a Low Temperature Reactor. This will make the application of the distillation process independent of power development.

The cost of sea-water conversions is heavily influenced by the cost of the distillation equipment. The development of big, industrially sound, distillation plants is in its initial stages. It may thus be expected that, in due years, cost of equipment will trend downward, contributing along with more efficient processes, to a lower price of distilled sea-water.

MAGNETIC PARTICLE COUPLING FOR INDUSTRIAL DRIVES

A magnetic-powder torque-transmission device is now available to British industry which, it is claimed, fulfils all the duties of a friction clutch, but without "snatch" or wear; and which offers the smooth take-up and high controllability of the eddy-current coupling without the disadvantage of continual slip and the consequent loss of efficiency. As noted in our first report of the Mechanical Handling Exhibition last week, the new magnetic particle coupling has been developed for heavy-duty applications by S. Smith and Sons (England) Limited, Witney, Oxfordshire. It is based upon an American invention; the licensors under the basic American patents are the Eaton Manufacturing Company, Cleveland, Ohio, and their subsidiary, the Dynamatic Corporation, Kenosha. In addition Smith have an agreement whereby patents and technical information are shared with the German AEG company who, through their subsidiary EMG, have also been carrying out industrial development work on the basic patents.

Fig. 1 shows a cross-section through the coupling. There are two rotors, one within the other, separated by an air gap; to one of the rotors is coupled the input shaft and to the other the output shaft. The air gap contains a quantity of ferromagnetic powder. Around the two rotors is a stationary field member containing an exciting coil, with an air gap between it and the input rotor. When current is applied to the coil, magnetic flux is created which crosses the air gap between the stationary member and the input rotor, and the powder gap between the input and output rotors. When the flux passes through the powder, the particles are attracted between the pole faces in such a way

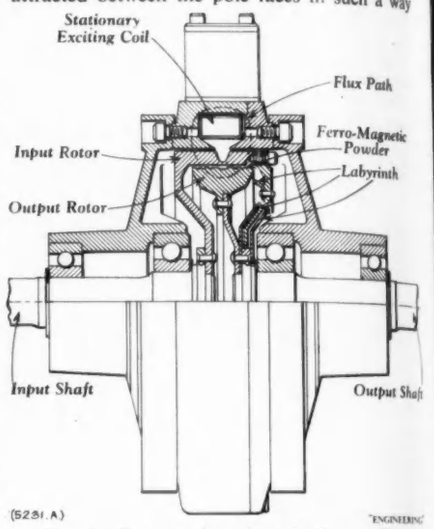


Fig. 1 Cross-section through the coupling.

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[11] Brenan, John B., Atomic Energy Clearing House (9 July, 1956).

that torque proportional to the degree of excitation is transmitted from the input to output rotors.

The component parts of the coupling are shown in Fig. 2. The stationary field member is in the left background. In the centre are the input rotor (right) and the output rotor and back plate (left). When assembled, the output member is fully enclosed, and the input member has integral with it a labyrinth plate to retain the magnetic powder within the working area.

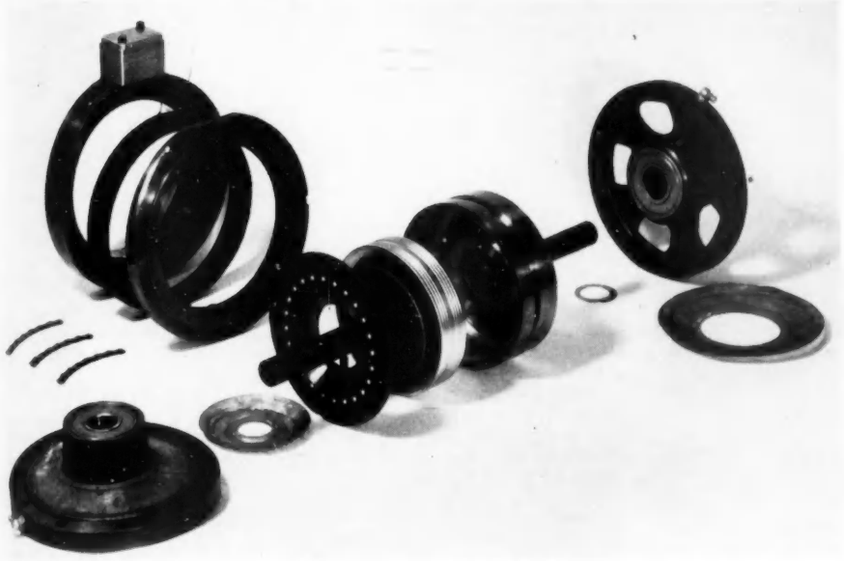


Fig. 2 Components of the coupling: stationary field member at the rear, input (right) and output (left) rotors in the centre.

The principle of the magnetic particle coupling is based on the discovery that if a free-flowing powder with ferromagnetic properties—e.g., pure iron powder—is subjected to a magnetic field, the powder grains arrange themselves in columns along the lines of force between the poles in such a way as to provide the best possible flux path.

NO STICK-SLIP

Since the particles are irregular in shape, and in fact potentially wedge shaped, this produces a secondary effect: the powder columns exert a force on the magnetic poles parallel to the lines of force, and therefore normal to the pole faces. Thus, any attempt to move either pole relative to the other at right angles to the lines of force produces a resisting force tangential to the pole face equal to the product of the force exerted by the column of powder against the pole face and the coefficient of friction between powder and the pole face.

Since the average particle size is of the order of 0·0005 in mean diameter, the complete clutch consists of an extremely large number of these magnetically loaded columns exerting pressure between the pole members. Under slipping conditions the pressure-exerting columns will be breaking and reforming, with the powder particles continuously re-arranging themselves. The net result is that this coupling has an important difference from a normal friction clutch—it has no " stick-slip " characteristic, i.e. the static and slipping coefficient of friction are the same, averaged over the whole coupling. Thus, for a given magnetic field, the maximum torque which the coupling will transmit just before slipping commences is the same as under slipping conditions. Take-up is therefore as smooth and free from judder as that obtained with a hydraulic device.

When the coupling is disengaged by de-energising the exciter coil, the particles move outwards under centrifugal force and are no longer in contact with the inner pole member. Hence there is no residual drag between the pole members; also, since the particles re-arrange themselves at each engagement, questions of friction-lining wear, glazed high spots, etc., which are features of normal friction clutches, do not arise.

The torque transmitted by the pressure of the powder columns on the pole pieces is directly proportional to the magnetic flux in the powder, which in turn is almost directly proportional to the exciting current. The device is therefore very suitable for remote control, by electrical means, of the torque to be transmitted.

A valuable feature where accurate control of torque is required is an effective coefficient of friction which is virtually unaffected by temperature. (There is a second-order change of torque with temperature for a given applied voltage because of the effect on current of the increase in coil resistance with temperature, but this can readily be corrected, if important, by means of a constant current control.)

MINIMUM SERVICING

From the point of view of reliability and serviceability, the magnetic-particle coupling offers several advantages: there are no axial moving members for engagement, or other " weak links " in the drive. In the fully-energised condition the input and output rotors become, in effect, one solid mass; there are no driving pins, dogs or splines to wear. There are no slip-rings or brush gear, hence no chance of inconsistent behaviour due to poor contact. No lubrication servicing is necessary since the ball bearings are sealed assemblies. Thus, maintenance is reduced to the minimum; at the periods when bearing overhaul is called for, a fresh charge of pure iron powder would be inserted; the opportunity would be taken to examine the pole faces of the rotors and, if necessary, they would be replated—but this would be an extremely rare occurrence.

The exciter coils may be wound for 12 V, 24 V or 180 V d.c. supplies. According to the application, the control system may be simply an on/off switch with, possibly, a manual rheostatic controller; or it may be a complex electronic circuit or magnetic amplifier designed to give a specific characteristic to the mechanism concerned.

The industrial coupling is available in the following torque capacities: 0·33, 1·0, 6, 12, 25, 50, 100 and 200 lb-ft. The present range is designed for intermittent slip operation, progressive engagement, etc.; but later Smith expect to introduce a magnetic-particle coupling for continuous slip application, such as continuous torque limitations or speed control. Provided that adequate means for carrying away the heat generated under slip conditions are provided, the magnetic-particle coupling is well suited to such applications, since the metallic working faces of the coupling give excellent heat transfer.

Couplings working under continuous-slip conditions have already been undergoing field trials. Satisfactory results have been achieved in the control of tension for film winding and for materials such as plastics strip. Other applications of the magnetic-particle coupling already in service are the remote control of camera equipment where smoothness of take-up is of paramount importance; the control of sweet-mixing mills, in a duplex form having a single output shaft capable of rapid reversal rotation; and the accurate control of alternator speed from a fluctuating drive source.

The coupling can also be used as a brake and ultimately it will be made available with the output shaft locked solid for this purpose. It should be noted, however, that, in its present form, the coupling, when used as a brake, does not " fail safe."

Concurrently with the development of industrial drives, Smiths have for the past three years been working on the automobile application, and they expect to announce a new British automatic transmission for cars in the " not very distant future." Already in France the Peugeot company are marketing cars with semi-automatic transmissions using magnetic powder couplings made under licence from S. Smith and Sons (England) Limited.

NAVAL STRIKE AIRCRAFT

Shown in the accompanying illustration is the NA.39 naval strike aircraft which recently flew for the first time at the Bedford airfield of the Royal Aircraft Establishment. The NA.39, constructed by Blackburn and General Aircraft Limited, Brough, East Yorkshire, is designed as a low-level high-speed strike aircraft. It is powered by two de Havilland Gyron Junior turbojets.

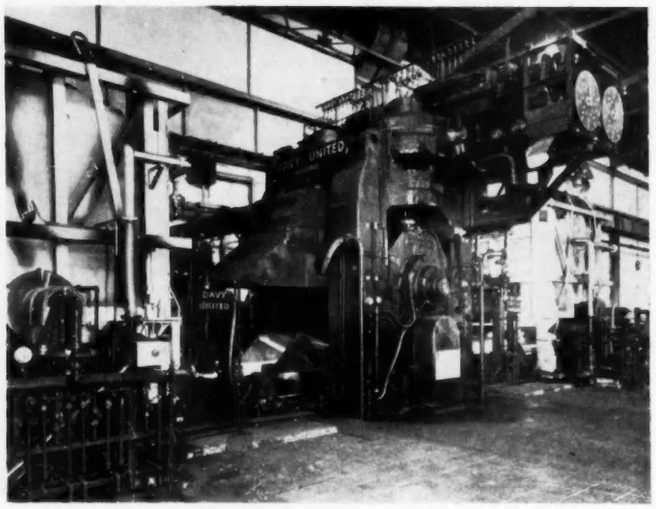
To a large extent, the NA.39 is of integrally-stiffened construction. The unusual fuselage outline is designed to reduce transonic drag to the minimum—the manufacturers claim, in fact, that " the NA.39 is the first aircraft in the world to embody full area-rule design." To reduce landing speed, the wings are equipped with boundary-layer control, air for this purpose being bled from the Gyron Junior compressors, which are specially designed for such applications, with an air-bleed manifold provided around the engine's combustion chamber.

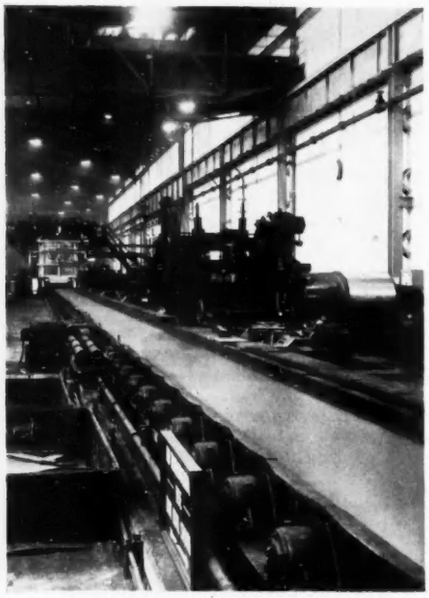
The NA. 39, a long-range aircraft capable of carrying an atomic bomb, is said to be suitable for both land and ship-based operations; and,

in fact, according to the 1958/59 Defence White Paper, it is now under consideration for the Royal Air Force as well as for the Royal Navy. The United States Government has taken a substantial practical interest in the development of the NA. 39: as part of the Mutual Weapons Development Programme they have contributed both financial aid and hardware to assist in the development testing.

Production

INCREASING PRODUCTION OF WIDE STAINLESS STEEL STRIP

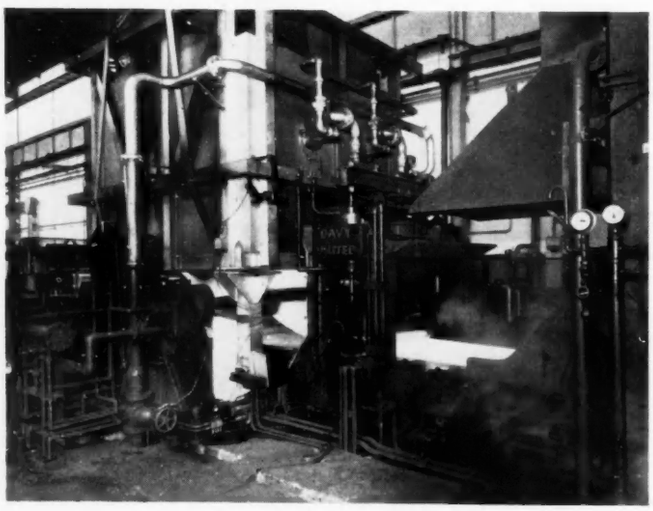




(Above) A major item in the modifications at Shepcote Lane is the hot Steckel mill. Both the coiler furnaces can be seen in this view.

(Left) The position of one furnace in relation to the mill is seen in this view along the run-out table. On the right is the "mould" shear, not in use and run out of the line.

(Below) In this closer view of one of the coiler furnaces, the hot strip can be seen passing up to the coiler.



Shepcote Lane Rolling Mills, Sheffield, which are jointly owned by Firth-Vickers Stainless Steels Limited and Samuel Fox and Company Limited, in the proportion of two-thirds and one-third, respectively, were laid down in 1953 as the first producers of wide stainless steel strip in this country. In their original form the works produced hot rolled coils of up to about 1,500 lb, which were flash-butt welded end to end to make coils weighing up to 5 tons, and then cold rolled to finished gauge. Continuous softening and descaling equipment was provided, and the product was softened and descaled strip in coil, from 24 in to 1 metre wide and from 14 to 30 gauge thick. These coils were available for sale or for passing to associated plants for bright polishing or cutting.

At the time when the plant was built it was envisaged that at a later date it would be necessary to hot roll longer coils from larger slabs, and modifications to enable this to be done have now been completed. At the same time certain other plant modifications and additions were also carried out. The hot mill can now accept 6 in thick slabs weighing up to 8,000 lb, and produce strip up to 41½ in wide in coils 350 to 400 ft long and down to 0·10 in thick, ready for cold rolling. Additional equipment in the finishing section of the works includes a new skin-pass mill and a new softening and descaling line. The greatest single alteration has been the conversion of the former orthodox four-high hot finishing mill to a hot Steckel type, which has the coilers inside gas-fired furnaces. This arrangement maintains the strip temperature necessary to roll the longer coils.

Stainless steel slabs are received by rail or by road from an associated works, and are unloaded by overhead crane and an 8 ton Freightlifter to a storage area, from which they pass to a slab flame cutting section. Here they can be cut to length as required, and a small taper cut on each end of all slabs 32 in wide and over. This gives a lead into the coiler slots of the Steckel mill; the normal end shearing removes the tapered ends.

Slabs cut and taper-ended where necessary are then dressed on the surface in a battery of slab grinding machines, and pass to a Priest town gas-fired pusher furnace where they are raised to rolling heat. A newly-installed transfer table enables hot slabs to be withdrawn from the furnace and recirculated should there be a temporary hold-up in the mill. It also allows for special dummy slabs to be circulated through the furnace when a change of steel specification, involving a different rolling temperature, is being made. Discharge from the furnace is to the ingoing roller table of the hot roughing mill. This is the original Davy-United 35 in two-high reversing mill with 72 in wide rolls, and it has associated with it a pair of 24 in edging mills. Extra power has been provided for these rolls. Seven, nine or eleven passes are required, according to slab size, in the roughing mill before the rolled-out slab now 1 in thick or less is passed to the mill run-out table, where a new 1 in by 48 in upcutting electric shear squares both ends; motorised adjustable side guards preceding this shear centre the slab for accurate end squaring.

COILING FURNACES

Immediately beyond the shear is the hot Steckel mill, which is based on the existing Davy-United four-high 27 in and 53 in by 48 in reversing mill. Originally the mill operated as a straightforward four-high reversing hot mill, but to conserve heat in the much longer lengths now being rolled it is equipped with a town gas-fired furnace suspended over the roller table at each side. A pair of pinch rolls is fitted at each side, between the mill housing and the furnace. Coilers are mounted in the furnaces, and the operating procedure now is to roll the reduced slab or "breakdown" from the roughing mill and coil it inside the two furnaces alternately. Five or seven passes in the hot Steckel mill are sufficient to reduce the material to cold rolling gauge, when it passes via the mill run-out table to the upcoiler.

A new B.T.H. 2,800 h.p. motor has been added to supplement the existing finishing mill motor of the same power, and the rolling speed remains as before—460 to 920 ft per min. New screwdown gear has also been fitted, with twin motors of 200 h.p., and the screwing speed is from 0·498 to 4·98 in per min. Since it is impossible to feed the strip ends into the furnace mounted coilers under manual control, electronic controls, set in operation when the moving end of the strip crosses a jet of air, ensure that the strip end and the coiler gap movements are synchronised. Davy-United loadmeters are fitted under the finishing mill screws to measure the rolling load, and a continuous thickness gauge of the same make, using radioactive isotopes, measures the gauge of the hot strip.

A down-cut shear was installed near the end of the run-out table in the original layout, to provide cut lengths of hot-rolled material, or "moulds" for use in an associated hand rolling mill on another site; this feature has been retained, modified in some details to suit the new conditions. When the shear is not being used it can be traversed hydraulically out of the line.

At the end of the run-out table a new upcoiler has been provided, together with a new conveyor system running at right angles to the mill pass line to take coils into the adjoining cooling and storage bay. This equipment is designed to handle coils from 33 in to 42 in diameter, up to 8,000 lb in weight, and at temperatures of up to about 600° C.

A coil build-up and edge-trimming line adjoins the cooling bay, and in this line hot rolled coils are welded end to end to form coils of any

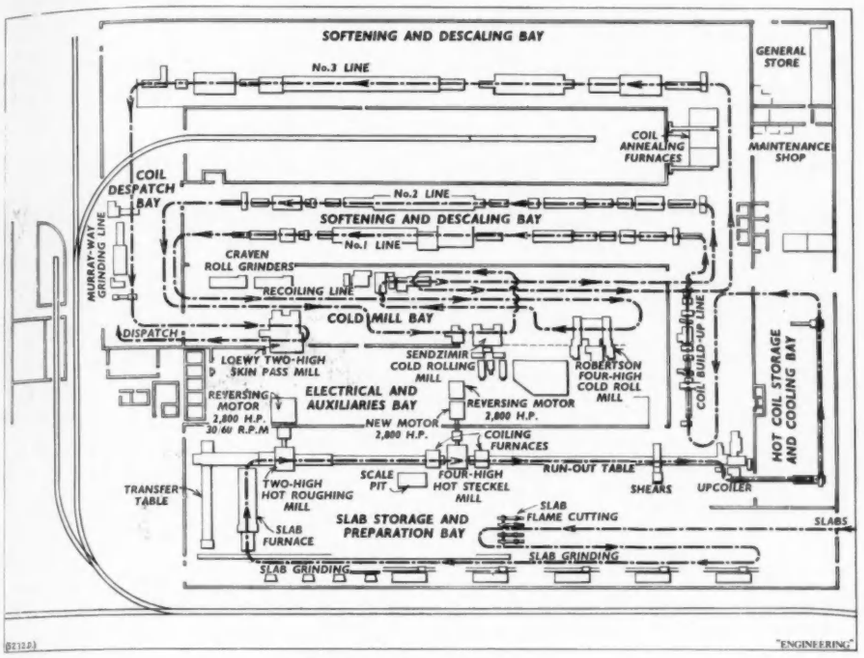


Diagram of material flow.

required weight ready for cold rolling. Before going to the cold mill, the coils pass through No. 1 softening and descaling line, which, like the other two lines in the plant, was supplied by the Wellman Smith Owen Engineering Corporation Limited. The line is fully continuous and automatically controlled, with automatic tracking of the strip edges to ensure that the strip passes through in a straight line within closely defined limits, and so produces a true coil.

COLD ROLLING

There are two cold rolling mills, the first cold reduction normally taking place on a Robertson four-high mill with rolls 17 in and 49 in by 50 in. This mill is part of the original equipment of the works, and is retained in unaltered form. After the first cold reduction the strip passes to an adjacent re-coil line, and thence to No. 2 softening and descaling line, which runs parallel with No. 1. This line was also in use before the modifications to the works began.

The second cold rolling takes place in a Sendzimir 2R40 mill, that is, a cluster mill of 40 in nominal width, which again was part of the original equipment. Steel work rolls are used for all passes in this mill except the finishing pass, when tungsten-carbide rolls are substituted. Quick and easy roll changing, and the fact that the work rolls are not driven, make the Sendzimir mill ideal for this method of rolling.

After final cold rolling the material passes once more through the re-coil line and so to the third softening and descaling line. This No. 3 line has been installed as part of the re-equipment scheme. Like the other two, it is an automatic and continuous line, generally similar to the older ones, but incorporating improvements suggested by operational experience. The line is 474 ft long, and allowing for the mechanical loopers about 750 ft of strip is in transit. From the feed end the principal units of the line are: a pay-off reel, shear, leveller, spot welder and pinch rolls leading to a mechanical looper and a degreaser. Pinch rolls follow, and the strip passes into the gas-fired softening furnace and its associated cooler. Then, after passing through a catenary control unit and further pinch rolls, three acid tanks are entered in succession followed by a washer and a drier. Next comes a visual inspection point, and the second mechanical looper, followed by shears and a Reavell-Askania air-hydraulic strip tracking device. Finally, there is the tension reel on which the strip is coiled.

FINISHING

The final finishing operation is skin-passing on a two-high mill which has been added as part of the new scheme. This mill, made by the Loewy Engineering Company Limited, has 26 in by 48 in forged alloy steel rolls with a minimum scleroscope hardness of 95. They are mounted in four-row roller bearings, and are gear driven by a 300 h.p. motor; the rolling speed is from 250 to 500 ft per min. Loading is hydraulic, with very close control, giving very uniform surface quality. A hydraulically collapsible coiler and decoiler are provided, giving very accurate tension control. One pass only is given in this mill, and the coil is then ready for despatch.

Among the ancillary equipment installed is a battery of Murray-Way abrasive belt wet grinding machines, consisting of three grinders in tandem, with the necessary coiler and decoiler. Coils are diverted from the main flow line to pass through the Murray-Way line as required; not all the strip is ground.

On the Shelf *By Frank H. Smith*

The preliminary programme is now available of the Glasgow annual meeting of the British Association. Most people know the address of the B.A.—Burlington House, Piccadilly, W.1.

In the January number of *The Library Association Record* there appeared a report by the Committee of the University and Research Section of the Library Association on the "Availability of Theses." The operative word is "availability" and the Aslib yearly "Index to theses accepted for higher degrees" does not, of course, cover this. It would seem that the Library Association Committee met frustration after frustration but they "will continue their efforts to persuade British universities to accept fully the desirable standard of availability which they have suggested, namely:

(i) That at least one copy of every thesis accepted for higher degrees should be deposited in the university library.

(ii) That, subject to the author's consent, all theses should be available for inter-library loan.

(iii) That, subject to the author's consent, all theses should be available for photo-copying.

(iv) That authors of theses should be asked at the time of deposit to give their consent for (iii) in writing, and that this consent should be inserted in the deposit copy of theses."

It is really rather fun when a journal which one would expect to be highly specialist produces an article on a subject completely foreign to its tendency. *Esso Magazine*, for instance, one would expect to be devoted entirely to oil and fringe subjects but the winter 1957-8 number contains the first of an authoritative series on "Local Government." It also has a delightfully illustrated piece on "The fascination of toys." Regular readers of the magazine will not, of course, be surprised to find this sort of article in it but I feel sorry for the student of local government (or of toys for that matter) who will probably be unaware of such a source for such material. This raises the question of how those students can be made aware of them? The average compiler of bibliographies on the subjects simply would not think of an oil house journal as producing them.

In view of the confusion that exists on the definition and duties of an engineer, I feel that a wider public should read "A Fully Educated Engineer" by Dr. W. Abbott in the April *Journal of the Junior Institution of Engineers*, which costs 5*s*.

Clipper Travel is the magazine produced by Pan American World Airways for its friends and, presumably, for passengers. It is mostly in the American idiom but it was still something of a shock to see an article on wonders of the world with the title "Greeks Build Parthenon Atop Acropolis." The paragraphs did nothing to dispel the shock, with titles such as "Big dig nets 60,000 relics"; "Where Greek Tragedy had its première"; "Parthenon explodes in 1687" (this seems to have no relevance to what follows) and, finally, "Byron puts curse on Lord Elgin." I am proud to see that the writer of this salute to Greek culture is Julie Smith.

The preservation properties of cold storage must be catching since the International Institute of Refrigeration, 177 Boulevard Malesherbes, Paris, 17e, are only just announcing the availability of the *Proceedings : IXth International Congress of Refrigeration*, held in 1955. The full set costs 30 dol.

It doesn't do to try to be cleverly funny. On 7 March, page 309, I wound up a piece on the American Institute of Industrial Engineers, in which I had been rather unkind, with "what *is* a research abstract ?" I had a most courteous letter back from the Assistant Professor of Industrial Engineering at Washington University, Saint Louis, Mo., U.S.A., thanking me for bringing the AIIE to the notice of readers and saying "By the way, a research abstract is an abstract of a research article." And that puts me in my place.

McGraw Hill's annual catalogue is a hefty affair that takes a bit of wading through and a sectional list on mechanical-engineering books which they have just produced is a nice handy size that will not take up too much room on the desk. It is divided into mechanical engineering (which is again divided into sub-sections), plant engineering, tool and die engineering, manufacturing processes, automotive mechanics (which includes aeronautical engineering) and aircraft maintenance and repair. There is, unfortunately, no title or author index. Incidentally, in May, McGraw Hill will be publishing the fourth volume of the *A.S.M.E. Handbook*.

Enthusiasts on woods (not bowls players) may like to know that Interscience Publishers are handling a revised edition of the fourteen-volume *Encyclopaedia of American Woods*, published by R. B. Hough from 1888 to 1928. The new work will be of 15 volumes and Volumes I and II are priced at 25 dol each.

Continuing **Production**

VAUXHALL MOTORS' DOUBLE-OUTPUT PLANT

A new building of 1½ million sq. ft area—a major feature of the Vauxhall extensions.

IN 1954 Vauxhall Motors Limited, Luton, embarked on a very large programme of works extension and modernisation. Originally conceived as a five-year plan, the work was speeded up in 1955, and it is now virtually complete. The bare statistics of the scheme alone are impressive. At a cost of £36 million the company's productive capacity has been raised from 130,000 to 250,000 cars, vans and trucks a year. Basically, the plan involves the complete removal of truck manufacturing to the company's branch factory at Dunstable, about five miles from the Luton works, and the erection and equipment of very large extensions at Luton. The major items of expenditure were £1½ million for developing land, £13 million for buildings, and £21½ million for new plant and equipment. New buildings include one of 1½ million sq. ft in area at Luton, and extensions at Dunstable. At Luton the new building houses a press shop, car body building, paint and trim shops, and final assembly line. Extensions to existing buildings at Luton have also been carried out, and there is a new central boiler house, a paint mixing building, oxygen and acetylene stores, and an effluent treatment plant. With its new facilities the Vauxhall company produces a greater proportion of its component parts than ever before, and ranks as one of the largest vehicle manufacturers in Europe. Production first began in the new building with the Victor.

Part of the new building is occupied by the press shop which contains 222 presses, many of them of large size.

PRESSINGS

The new car production building is 1,450 ft long and 900 ft wide. Of this a space 900 ft by 350 ft is occupied by the press shop. A steel stores 100 ft wide runs the full length of the shop, and is served by three 25 ton overhead electric travelling cranes. There are 11 bays in the press shop, 9 of them having a continuous basement, the presses being supported by a steel girder network. One bay is held in reserve at present, for future additions to press capacity. Overhead cranes, seven of 30 tons capacity and two of 50 tons, serve the nine production bays. Most of the presses, of which there are 222, are British Clearing machines, of the underdrive type, the sizes ranging up to 156 in wide, and 1,500 tons capacity. Three of the presses are Schuler 9 station transfer-feed machines, which are used for smaller components such as fan pulleys, and for some deep-drawn pressings. These machines are coil-fed and can produce up to 900 components an hour.

Mechanisation is employed extensively, much of the equipment being of Vauxhall design and manufacture. Shuttle loaders are used on many of the presses, and on multi-spot welding machines which are set up in line with the presses. Compressed air-operated unloaders, synchronised with the press stroke, and equipped where necessary with turn-over mechanisms, are used in the press lines, together with band conveyors for follow-through operation.

Scrap is disposed of beneath the presses, a network of eight slat conveyors extending between the lines. All the conveyors are controlled by the operator of a scrap baling press which produces bales of 4 or 5 cwt. A further conveyor transfers the bales to an adjacent loading dock for despatch by road vehicle.

Ancillary equipment in the press shop includes guillotines, blanking presses, coil feed blanking machines, machine tools for tool and die maintenance and a Bliss bedding and spotting press. An overhead monorail conveyor carries welded assemblies from the press shop to the neighbouring building shop, descending en route to a 30,000 sq. ft storage basement.

BODY BUILDING

An area of 353,400 sq. ft is devoted to body building, 223,100 sq. ft being used as the actual production area, with 106,000 sq. ft for pressed panel storage and 24,300 sq. ft for producing welded assemblies for use in the body shop.

A system of six overhead conveyors feeds the shop with components and sub-assemblies and there are two floor level conveyors on which the bodies are built. One of these, 828 ft long, is used for body welding. It is an endless conveyor in the form of a rectangle. The second conveyor, 2,375 ft long, is for body finishing; doors and fittings being added, and finishing, polishing, and surface rectification prior to painting being carried out on this line. A further conveyor 225 ft long, is used for door assembly.

On the body welding conveyor 42 jig trucks of special design travel continuously through the welding stations in synchronisation with the component conveyors so that the parts required arrive at the correct time. The body finishing conveyor is a pegged floor chain which pulls a large number of light trucks through the finishing stations. Dressing of welded joints is the first operation in this line, and the bodies proceed to sanding booths, door and boot-lid fitting points and inspection points, and finally to a transfer point where the body is lifted from the conveyor truck and slung on an overhead storage conveyor ready to proceed to the paint shop.

PAINTING

Situated on the first floor of the new block, the paint shop occupies an area of 91,125 sq. ft. A penthouse above of 83,531 sq. ft floor area houses drying and stoving ovens, ventilation plant

and paint pumping gear. All the paint used is mixed and stored in a separate building and pumped to the paint shop through 18 separate pipeline systems. The paint shop is served by a system of synchronised conveyors which carry the body shell (complete except for the front wings and bonnet and some small fittings) through the entire painting system.

The first conveyor is for phosphating. It includes a storage run which will hold bodies for an hour, thus ensuring that the phosphate plant is empty during meal breaks. The second conveyor takes the body through underbody dip, primer spray, primer drying and then back to the paint shop for underbody sealing. Sanding follows and then the bodies are lifted by the conveyor to the penthouse again for drying. Colour spraying follows with another journey to the penthouse for stoving. Paint, in both the undercoat and finishing sections, is sprayed by a battery of four guns which come into action automatically when the body passes a photo-electric cell, and travel through a curved path controlled by cams to suit the body profile. Finally the bodies pass to the third conveyor which is of the floor truck type, and takes them through the polishing section. The three conveyors total 7,139 ft in length. Equipment and conveyors similar to those used for the body shells are provided in the paint shop for smaller parts such as bonnets and front wings.

BODY TRIMMING

In the trim shop, which is on the first floor of the new building, the central feature is the trim conveyor, 3,060 ft long. It carries 167 body shells on lightweight trucks pulled by a pegged floor chain. The trim shop occupies 218,700 sq. ft and the trim stores on the same floor cover 60,750 sq. ft. A further area of 26,325 sq. ft in the basement is devoted to seat spring-case production. Purchased items, such as body hardware, carpets, glass and electrical fittings, are received by road direct to the stores, and a number of sub-assemblies such as steering wheels and columns, bonnets, and upholstery are prepared in the trim shop at convenient points adjacent to the main conveyor. Sub-assembly conveyors are used where applicable, as for example, for sewing operations and for seat assembly.

Body shells are fed from the paint shop conveyor to an automatic marshalling section and thence to the main trim conveyor. This runs the width of the shop, turns through 180° and runs back again for about half the distance. It then turns through a right angle and runs for 1,150 ft to the end of the shop. A bridge 15 ft high and 50 ft span lifts the conveyor above the shop floor at one point so that traffic can pass across the building. On reaching the far wall the conveyor again turns at right angles and passes through a tunnel 100 ft long in which batteries of high-pressure water sprays are used to test the waterproofing of the body shell. A second water spray ensures that rectification measures are effective. Another turn of 180° then causes the conveyor to run back for about 800 ft parallel with the previous run. Hot air ducts dry the bodies as they leave the water test area. Finally a turn of 90° brings the bodies, now completely trimmed, to a point alongside the marshalling bay. Here they are lifted by air-hoist and lowered through a hole in the floor to the car assembly line which runs below.

MECHANICAL UNITS

Engines, gearboxes, axle components and other mechanical parts are machined and sub-assembled in a separate building covering 19½ acres, near to the car production block. In this building the engine, gearbox and axle section occupies an area 1,760 ft long by 480 ft wide. There are three unit assembly lines, dealing with engines, front axles and rear axles respectively, and these sub-assemblies are transported to the car assembly line by an overhead monorail conveyor having a circuit length of 2,340 ft. It is synchronised with the final assembly line.

Extensive use is made of transfer machines. Cylinder blocks, for example, are machined on a line which consists of a Weatherley Oilgear broaching machine of 6 stations, a Kearney and Trecker 19 station machine, a 13 station Ingersoll, a 6 station Ingersoll, a 15 station Barnes, a 33 station Barnes, and a 15 station Ingersoll. Over 1,400 machining operations are performed by a group of 32 men. Closely allied with the cylinder block line is a 20 station Sundstrand transfer line, which machines the clutch housings; these are bolted to the cylinder blocks and receive a final series of machining operations in position. Both six-cylinder and four-cylinder blocks are produced on these machining lines, and the change from one to the other can be made in about two hours. Similar methods are used for cylinder heads.

Crankshaft lines for both types of engine also make use of transfer machines, and a Sigma automatic measuring station, giving both visual and Hollerith card records, is incorporated. Pistons and connecting rods, camshafts, valves, flywheels and starter rings are also made in this shop, automatic and semi-automatic machinery being used extensively. Shock absorbers are made completely in a separate section of the shop, fully equipped to form what is virtually an independent factory.

A further section of the shop is laid out for gear making. One gear cutting line is a battery of six Churchill gear hobbers, with fully automatic component transfer, and there are also three sets of four-in-line gear hobbers. Continuous-flow heat treatment furnaces, with fully-automatic temperature control are installed. Gear cases are machined on a Snyder 53 station transfer machine, which has automatic off-loading, and is completely controlled by one man. A slat type bench level conveyor is used for sub-assembly of gearboxes; it is served by a 630 ft monorail conveyor bringing components. Completed gearboxes are delivered to the engine assembly line by a further overhead monorail conveyor, having a circuit length of 3,010 ft.

Crown-wheel, pinion and differential gear cutting machines represent probably the greatest capital investment in machine tools in the shop. There are 155 machines in the section, mostly of Gleason manufacture. Rear axle housings are machined on a 26 station Cross transfer machine, and axle shafts have the splines rolled on them in a matter of seconds, as compared with four minutes, which was the time taken when they were hobbed. Assembly of rear axles is done on a double-strand conveyor running at bench level. This conveyor delivers the assembled units to the main conveyor leading to the car assembly line. A similar arrangement is used for the front axles.

Engines are assembled on a 345 ft slat type bench level conveyor, at the end of which there is a "motoring" section. At this point a system of electric motors and pumps is provided, which attach themselves automatically to each finished engine and drive it round at 470 r.p.m., warm clean oil being flushed through at the rate of 2½ gallons a minute. The engine and motors travel together for 27 to 30 minutes before the engine is disconnected and sent off on the conveyor leading to the final assembly line.

FINAL ASSEMBLY

All the component sub-assemblies converge

(Above) A conveyor takes car bodies, after painting, through the body trim shop, where they are finished ready for the engine and axles to be fitted.

(Right) In machining engines and other mechanical parts, much use is made of transfer machines. This cylinder block line has 48 stations.

Continuing **Production**

After assembly cars pass to three high-intensity light tunnels where they are given a close visual examination, before passing for final adjustments and inspection.

on the car assembly line in the new building. The assembly shop is 1,000 ft long and 180 ft wide, and has a conveyor 960 ft long in two synchronised and linked lengths. A single-strand slat type conveyor, starting at bench level and rising slowly to shoulder height, comprises the first section, on which front axle, rear axle and engine units are mounted. A short distance along this section of conveyor is the body fitting point, where the complete body is lowered from the trim shop above to meet the mechanical units. Wheels are delivered by an elevator from the tyre fitting section in the basement, and run down roller conveyors to the assembly line. An automatic switching system diverts the wheels to each side of the line alternately.

When the wheels have been fitted the car is lowered automatically to the second section of the conveyor, a two-strand slat type, which finally descends to floor level. At the end of the line the cars are filled with petrol, oil, and water, and the engines are started, flexible pipes being attached to the car exhaust pipes to take the fumes out of the building.

After inspection on the line the cars are driven off to the headlamp and toe-in adjusting station, passing over a grid on the way to bring the shock absorbers to " life " so that the car will assume the natural position it will take up on the road. Toe-in adjustment is done with the front wheels on rollers, which rotate them at a speed equivalent to about 10 m.p.h. The car is then tested with the rear wheels resting on four sets of free-running rollers, so that the inspector can carry out a simulated road test in any gear.

The car is then driven on to one of three parallel floor level slat conveyors, which move it over a well-illuminated inspection pit and then into a high-intensity light tunnel, where a close inspection is made of the finish. Then the car passes to the final finish section, which consists of two parallel 492 ft long floor level slat conveyors. Spot spray booths for paint rectification occupy the first part of the conveyor run, then there are drying ovens and a body polishing section. Final inspection is the last operation, and the car is driven off for despatch.

Like the rest of the plant, the plating shop is mechanised with a conveyor system and automatic induction heating equipment for soldering radiator assemblies. Straight through automatic nickel and chrome, and copper plating lines can deal with 100 jigs per hour, each jig carrying 8 sq. ft of components—equivalent to 1,600 sq. ft of plated work.

SERVICES

Provision of services for the new production block was a major part of the project. Heating is by high-pressure hot-water from five oil-fired La Mont boilers rated at 70 million B.t.u. per h, at a pressure of 270 lb per sq. in. Two package type steam boilers, also oil fired, give 27,500 lb of steam per hour at 250 lb per sq. in for process work. All the boilers are installed in a new building adjacent to the new production block. Provision has been made in the shop heating system for maintaining the working areas at 65° F when the outside temperature is 30° F. In the body shop and main assembly areas space heating is combined with ventilation, with large Plenum units consisting of fan, heater battery and run of distribution ducting. All the space heating units are thermostatically controlled. Warm air curtains are provided at vehicle entrances to the building. In winter the ventilation system provides two fresh air changes per hour, and in summer, four to five changes per hour. Special ventilation equipment is provided for all points where hazardous or obnoxious fumes are given off, as for example at the final assembly line where cars are being run under their own power, and in the paint shop.

Compressed air is supplied by seven Atlas Copco compressors with a combined free air delivery of 22,540 cu. ft per min at 100 lb per sq. in.

For general lighting a system of 8 ft 125 W twin fluorescent lights mounted on continuous trunking has been used, giving an overall factory illumination of 30 ft-candles. Specialised types of lighting equipment, flameproof or high-intensity for example, have been installed where necessary.

NOTICES OF MEETINGS

British Computer Society

LONDON
" Four Years of Automatic Office Work," by T. R. Thompson. Caxton Hall, off Victoria Street, Westminster, S.W.1. Mon., 19 May, 6.15 p.m.

British Institution of Radio Engineers

LONDON
" Cold-Cathode Voltage Transfer Circuits," by J. H. Beesley. London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1. Wed., 21 May, 6.30 p.m.*

Chemical Society

LONDON
" The History of the Isoprene Rule," by Professor L. Ruzicka. Thurs., 5 June, 7.30 p.m.

Combustion Engineering Association

GLASGOW
Discussion on " A Survey of Boiler Cleaning Methods," at 10.30 a.m. and a Discussion on " A Comparison of Space Heating Systems," at 2.30 p.m. Scottish Region. Grand Hotel, Charing Cross, Glasgow, C.3. Wed., 11th June.
MANCHESTER
" Grit and Dust Collecting Equipment for the Smaller Plant." by Dr. C. J. Stairmand. North Western Region. Engineers' Club, Albert Square, Manchester. Wed., 21 May, 2.30 p.m.

Helicopter Association of Great Britain

LONDON
" Turbine Helicopters," by D. L. Hollis Williams. Royal Aeronautical Society, 4 Hamilton Place, W.1. Fri., 6 June, 6 p.m.

Incorporated Plant Engineers

LONDON
Debate on " In Planning a New Factory the Plant Engineer and not the Architect Should Have the Final Authority." London Branch. Royal Society of Arts, John Adam Street, Adelphi, W.C.2. Tues., 3 June, 7 p.m.*
BIRMINGHAM
" Tower Cranes," by A. Sutcliffe. Birmingham Branch. Imperial Hotel, Temple Street, Birmingham. Fri., 23 May, 7.30 p.m.
Open Discussion on " Ideas and Problems." Birmingham Branch. Imperial Hotel, Temple Street, Birmingham. Fri., 30 May, 7.30 p.m.
ROCHESTER
" Maintenance of Shell Boilers," by J. N. Williams. Kent Branch. King's Head Hotel, High Street, Rochester. Wed., 21 May, 7 p.m.

Institution of Civil Engineers

LONDON
" Multi-Storey Construction in Concrete," by J. A. Derrington. Tues., 20 May, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
" Standardisation of Control Facilities for the British Grid Communications, Indications and Telemetering," by P. F. Gunning; and " The Development of Communication, Indication and Telemetering Equipment for the British Grid," by G. A. Burns, F. Fletcher, C. H. Chambers and P. F. Gunning. Supply Section. Wed., 28 May, 5.30 p.m.*
ABERDEEN
Annual General Meeting and Film Evening. Scottish Centre. Robert Gordon's Technical College, Aberdeen. Fri., 30 May, 7.30 p.m.

Institution of Public Health Engineers

LONDON
Informal Discussion Meeting. Caxton Hall, off Victoria Street, S.W.1. Mon., 2 June, 6 p.m.

Physical Society

LONDON
" The Manufacture of Interference Filters," by E. Henderson; " The Supporting of Mirrors in Astronomical Telescopes," by G. M. Sisson; and " The Testing of Large Mirrors," by G. E. Manville. Optical Group. Northampton College of Advanced Technology, St. John Street, E.C.1. Thurs., 22 May, 2.30 p.m. (Tea at 4 p.m.)

Royal Society

LONDON
" The Institute of Aviation Medicine ": a lecture by Group-Captain W. K. Stewart. Thurs., 29 May, 4.30 p.m.*

Royal Society of Arts

LONDON
" The 1958 Brussels Exhibition," by Charles Hadfield. Wed., 28 May, 2.30 p.m.

Royal Statistical Society

LONDON
Annual General Meeting. " Long Term Demands for Fuel," by E. F. Schumacher. Study Section. London School of Economics, Houghton Street, W.C.2. Wed., 21 May, 6 p.m.

Society of Instrument Technology

LONDON
Annual General Meeting and Presidential Address. Manson House, Portland Place, W.1. Tues., 20 May, 6 p.m.
NEWCASTLE UPON TYNE
Annual General Meeting. Newcastle Section. King's College, Stephenson Building, Newcastle upon Tyne. Wed., 21 May, 7 p.m.

Women's Engineering Society

LONDON
" Rubber as Applied to General Engineering," by S. W. Marsh. London Branch. Offices of the Central Electricity Generating Board, Winsley Street, near Oxford Circus, W.1. Tues., 20 May, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

British Computer Society, 29 Bury Street, St. James's, London, S.W.1.
British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1. (MUSeum 1901.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke Street, St. James's, London, S.W.1. (WHItehall 5536.)
Helicopter Association of Great Britain, 4 The Sanctuary, London, S.W.1. (ABBey 5160.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institution of Civil Engineers, Great George Street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Public Health Engineers, 118 Victoria Street, London, S.W.1. (VICtoria 3017.)
Physical Society, 1 Lowther Gardens, South Kensington, London, S.W.7. (KENsington 0048.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck Street, London, W.1. (WELbeck 7638.)
Society of Instrument Technology, 20 Queen Anne Street, London, W.1. (LANgham 4251.)
Women's Engineering Society, 25 Foubert's Place, London, W.1. (GERrard 5212.)

THE DOMESTIC BATH

Semi-Automatic Production of Thin Castings

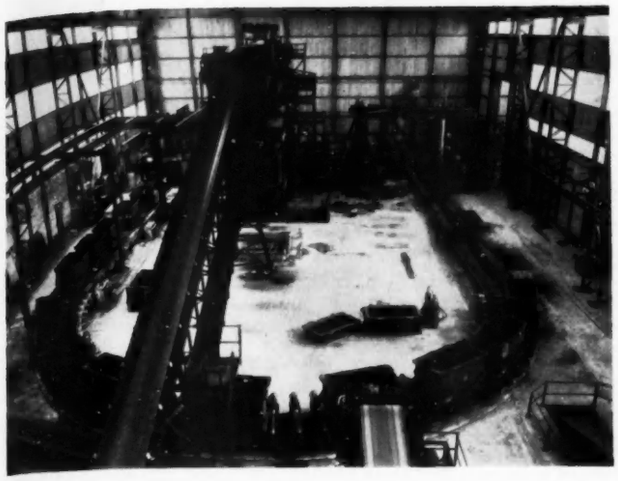


Fig. 1 Interior of main foundry building at Bilston Foundries' new bath plant, capable of producing a bath per minute. The twin double-station Herman mould-indexing machines are located at the open end of the "U" shaped conveyor track.

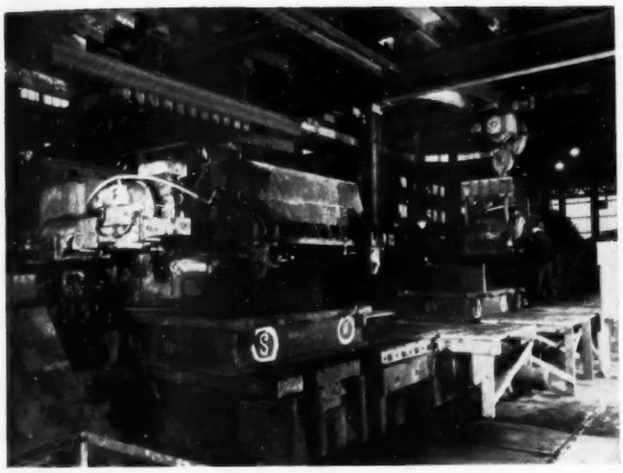


Fig. 2 Section of the moulding plant producing the bottom half of the sand mould (drag box). The pattern has been withdrawn and is about to be reversed and swung round into position for the next mould. Further along the track the top half of the mould is being lowered into position.

Fig. 3 The cope box with the top half of the mould being lifted from the pattern. On the right a predetermined weight of sand is pouring from the hopper into the steel moulding boxes.

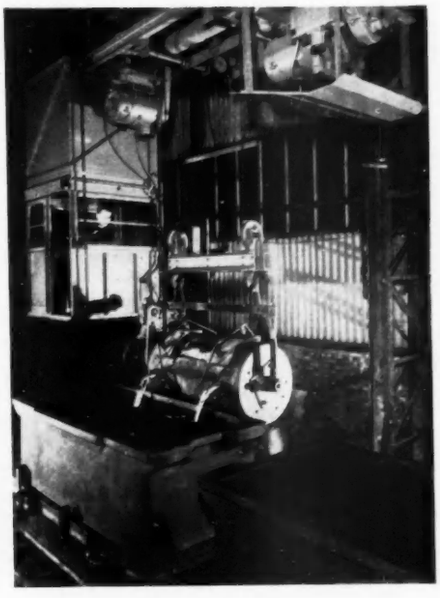


Fig. 4 The operator in the cab of the travelling crane controls the mould movement to and from the pouring station and pouring from the double-spouted ladle. Three moulds are poured at a time.

So much has been written during the last few years about the new industrial revolution and in particular of the transition from mechanisation to automation, most of which has been based on theoretical studies, that it is refreshing to see British industry putting it into practice. Furthermore, there is the question whether it is the new light engineering and electronic industries, or the older traditional industries of this country which can gain most from such a fundamental change in planning production.

That the spirit of adventure is not dead even in our well-established Midland foundries is evident from a visit to the new domestic bath manufacturing plant of Bilston Foundries at Batman's Hill, Cosely, Staffs. Here, on a site of some 13½ acres, has been brought together under one roof the most up-to-date mechanical handling, melting, sand milling, mould making, casting, finishing and electrical equipment to provide an integrated unit capable of producing the latest designs of Bilston baths—such as the "Magna" and "Atlanta"—at the rate of one per minute.

Since the war there has been a steady increase in the demand for cast and porcelain-enamelled domestic baths. This, perhaps, is not surprising when one considers the extensive rehousing schemes during this period and that even to-day about a third of the population of this country is still without private baths. In addition, there is the growing demand for a better standard of living in countries overseas so that there is every reason to expect that the company's present output of about 100,000 per year will steadily increase. This production has been achieved in the original Bilston foundries, in which the moulds are made by hand or by impeller type ramming machines, by working three shifts a day. The new plant will enable this level of production to be improved upon in a working day of eight hours with a potential of 400,000 per year and a reduction in man-hours per bath of about 75 per cent.

The high main building with its low pitch roof, brick frontage and five very large vertical windows, which forms the moulding and casting hall, the exposed steelwork of the open sided stockyard with its gantry crane, and the adjacent smaller flat-roofed buildings of the dressing and enamelling shops, despatch bays and amenities block, all combine to give the plant an efficient yet pleasing appearance in keeping with the orderly production lines of the fully integrated plant which these buildings house.

The process of making baths is essentially the same as that which has been developed over the years in the older foundry. Scrap, pig iron, limestone and coke are melted in a cupola furnace to provide a molten charge of grey cast iron, complying with British Standards specification requirements (B.S. 1452: 1956 Grade 10), which is then poured into sand moulds. The castings are then removed from the moulding boxes, shotblasted, reheated in a muffle furnace and the inside surfaces porcelain enamelled while the underside is spray painted. When designing the new plant full account had to be taken of the technical details of the various processes involved in bath production, in order to ensure that with the introduction of integrated fully mechanised processes, the founding art and skill acquired in the older foundry was also incorporated.

The moulding plant may be regarded as the hub of the new foundry. Here the "key" machines are two double-station Herman moulding machines situated at the open end of a "U" shaped conveyor track. These machines were built in the United States by Herman Pneumatic Company, Zelienople, Pennsylvania. At one station, the bottom half of the mould, or "drag" box is prepared by filling the box, which has been set in position over the pattern, with a predetermined weight of sand from the sand hopper. The sand is then packed with ramming weights and by automatic jolting for a given time (3 jogs per sec for 6 sec). The box is then lifted and indexed through 180°, rolled

Continuing **Production**

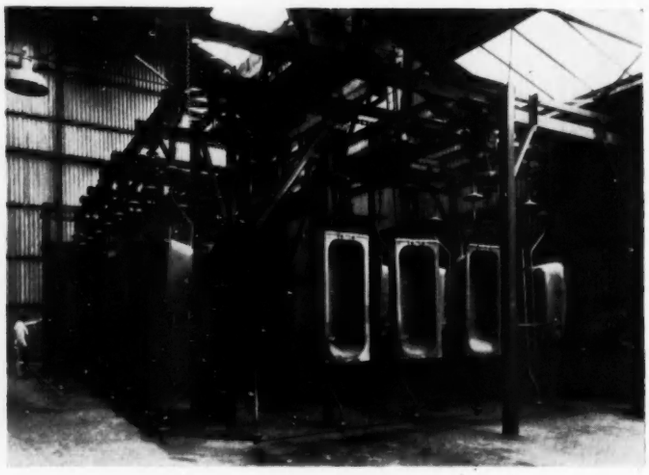


Fig. 5 An overhead conveyor system takes the castings from the foundry to the Tilghman mechanical abrasive cleaning plant, through which they may be passed at a rate of 60 per hour.

Fig. 6 Vitreous enamelling the interior of the baths at a temperature of 950° C. Two coats are given with reheats to complete fusion of the coat. A remotely controlled jig facilitates the sprinkling process.

over, the pattern removed, and the roller track lifted to take the box. The whole operation takes 60 sec and the bottom half of the mould starts along the conveyor track a few seconds after the pattern has been lifted and swung round into position for the next moulding box. Meanwhile the top half of the mould is being prepared in the cope box by the same procedure; it is then swung over by a 5 ton hoist to join the lower half of the mould already on the track and proceeds to the pouring station.

The control of the double spouted pouring ladle and movement of the mould is from the cab of the travelling crane handling the ladle. Each ladle carries enough molten metal for three castings, each mould taking 3 cwt. The rate of progress of the boxes is then controlled by rollers individually driven by geared motors and a series of flag stops to give sufficient time for metal solidification as it proceeds around the bend in the track and down the return "leg" to the casting removal station where the boxes are automatically hoisted on to a shaking machine. Here the sand falls through a grid and is returned by belt conveyor for reconditioning while the casting is removed by an overhead conveyor leading to the shot blasting cabinet and dressing shop. The mould boxes themselves are returned to the moulding machines ready for use again.

The main foundry building is dominated by the sand plant and towering belt conveyors. There are seven mills each capable of milling 40 tons of sand per hour and eight storage hoppers each of 30 tons capacity. A total of 24 belt conveyors and feeders varying in length from 10 to 250 ft, some of which run beneath the foundry floor, can handle up to 350 tons per hour; they are used for conveying conditioned sand to the moulding plant, returning used sand to the storage hoppers, and delivering sand to the mills for conditioning and bonding.

Two cupolas, each having a rated capacity of 17 tons per hour, are fed by an inclined S-type cupola charger which may be swivelled from one cupola to the other. In practice the cupolas are used on alternate days so that the lining of one can be fettled while the other is used for melting. A continuous stream of molten metal pours from the latter via a long spout to a hot metal receiver which can be tilted by the man in charge of the casting operations, to fill the pouring ladles. The cupola charge is made up from predetermined weights of raw materials. The required amounts of pig and scrap iron are loaded into the weigher, by means of a variable flux magnet suspended from a gantry crane. Coke and limestone in quantities as required, are added to the iron in the skips by vibratory feeders in the charging hoppers. Only one man is needed to control the charging of the melting plant.

The plant is electrically operated and the starting-up process, preceded by the sounding of a warning signal, is by switchgear operating in strict order of sequence so that one section of the plant does not start to operate before adjacent equipment is ready to feed or receive; special precautions are taken to avoid "build-up" at any location and an ingot casting machine converts to ingots any molten metal which should accumulate during a stoppage on the moulding plant.

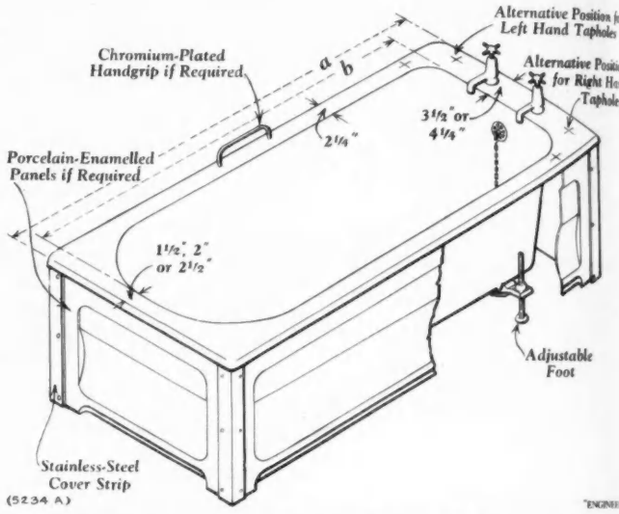


Fig. 7 Isometric view of "Atlanta" bath. Outside lengths (a) range from 4 ft 6 in to 6 ft, and corresponding widths from 2 ft 2½ in to 2 ft 4¾ in.

FINISHING PROCESSES

The castings are conveyed straight from the foundry to a Tilghman mechanical abrasive cleaning cabinet where the baths are shot-blasted at the rate of 60 per hour. They then pass through the dressing shop where any rough edges are ground off, and then to a spacious enamelling shop of 80 ft span and 180 ft length, designed to provide dust free conditions.

The enamelling process consists in giving the baths a ground coat to prevent oxidation, and then heating to 950° C in oil-fired muffle furnaces. At this temperature the baths glow red and have to be manipulated at a distance. From the furnaces they are lifted on to a special jig which is motor driven to rotate or swivel the castings in any position by press-button control. The porcelain enamel, blended to the desired shade of colour, is sprinkled uniformly on to the red-hot surface from containers manipulated at the end of long rods. The baths are returned to the muffle to enable the coating to fuse, and are withdrawn to apply a second coat of enamel, followed by a reheat and fusion in the muffle. The still hot baths are then allowed to cool slowly under hoods. In this way the glossy permanent enamel finish becomes virtually a part of the cast surface. Only the top exposed surfaces of the bath are enamelled; the underside is given a sprayed coating of protective paint. In the enamelling shop work is continuous, in three shifts, for the full 24 hours.

This spectacular new plant has cost about £750,000, of which the mould indexing machines cost about £45,000, the sand milling and metal melting plant each about £35,000 and the conveyor system, etc., about £250,000. In one respect, however, the plant fails to come up to expectation, and that is in the suppression of noise. Having provided the most excellent conditions for foundry work, space to move around, clean conditions, and the elimination of heavy handling, it is unfortunate that so little attention has been given to the reduction of noise and reverberant sound in the foundry hall which, during production, reaches a painfully high level. A considerable improvement in this respect could be achieved by enclosing the most serious sources of noise, such as the shake-out machines, with sound absorbent panels. Nevertheless, the new plant is certainly a model of advanced planning and layout for foundry production—an example of which Bilston, and indeed Britain, can be justly proud. The main contractors were Sir Alfred McAlpine and Son (civil engineering); James W. Ellis and Company (constructional engineering); and Pneulec Limited (plant supplies).

Research and Development

STRUCTURE AND PATTERN

Research at the U.S. National Bureau of Standards

The Annual Report for 1957 of the United States National Bureau of Standards reveals work in progress on a wide range of subjects. Certain aspects of the work are described below. The primary concern of the Bureau is, to quote the report's introduction, "the establishment of new and better standards of physical measurement and the development of techniques and instruments for using these standards throughout the nation." Activities are of two major budgetary classes: first, basic programmes that are supported by direct appropriations from the Congress; second, various projects undertaken for other government agencies with funds transferred from those agencies.

During 1957, the total funds set aside for both areas of activity, including construction and facilities, were 28,011,000 dol. Of this total, 10,010,000 dol came from direct Congressional appropriation for the basic programme, and the remaining 18,001,000 dol represented programmes conducted for other government agencies and private sources.

During the past year, considerable study went into a re-examination of the relationship of Bureau responsibilities to other agency requests. Bureau staff members and technical advisory committees reviewed the technical programmes and made recommendations for strengthening the basic research activities. New projects accepted from other agencies are now given a careful screening as to their appropriateness, in terms of their relation to Bureau objectives and facilities.

HOTTER AIRCRAFT

In order to meet the pressing technological and scientific demands for thermodynamic data, the properties of air and its constituents have been studied intensely in the past year. Such studies, under the partial sponsorship of the United States Air Force, were concerned mainly with observations made at high temperature. The equilibrium thermodynamic properties and the transport properties (viscosity, thermal conductivity, diffusion, and Prandtl number) of air at low pressures were determined. Under the sponsorship of the Atomic Energy Commission, the ideal-gas thermal functions for the atoms and ions of hydrogen, carbon, nitrogen, oxygen, and argon were established.

Investigations of the various modes of oxidation of propane, the simplest hydrocarbon which exhibits combustion reactions typical of the higher hydrocarbons used as fuels, have recently been carried out under the sponsorship of the Air Research and Development Command. Isotopic tracer studies of the slow, or cool flame, oxidation of propane-2-C^{13} have yielded information on the origin of many of the products. Findings generally confirm current theories of the cool flame mechanism.

Application of similar methods to the investigation of the hot flame, however, has revealed unexpected features of this reaction. For example, the lower hydrocarbon products of rich explosion flames, such as ethylene and acetylene, do not arise directly from a two-carbon fragment of the carbon chain of the fuel, but appear to be synthesised in the flame from simpler radicals or molecules by reactions as yet unidentified. Similar reactions take place in the thermal decomposition of propane at temperatures greater than 1,200° K. Thus there is an opportunity to study them in a high temperature system simpler than a flame.

The use of shock-wave heating is being investigated for possible application to the study of flame initiation, thermal decomposition, and flame reactions of mixtures outside ordinary inflammability limits.

As gas temperatures in turbine engines will soon exceed the operating range of currently used immersion temperature sensing devices, the need for new sensing elements has arisen. Particular interest has been shown in the development of an instrument that will sense gas temperatures from the radiating characteristics of the hot products of gas combustion. The Wright Air Development Centre has requested the Bureau to investigate emission and absorption by hydrocarbon combustion products. Observations have been made on streams of exhaust gas at temperatures from 1,000° to 3,500° F. Special emphasis was placed on the wavelength region between four and five microns, where many vibrational transitions of carbon dioxide occur. Considerable effort was given to the theoretical and experimental study of intensity gradients and their effects on the accuracy of sensing devices. The feasibility of an airborne pyrometer was established.

The increasing use of titanium and its alloys has led to a demand for more information on their mechanical properties as affected by stress concentrations, stress systems, and subzero and moderately elevated temperatures. A study was therefore made to evaluate the behaviour in tension of annealed commercially pure titanium and titanium alloy (4 per cent aluminium, 4 per cent manganese) at temperatures ranging from − 196° to + 100° C under stresses such as those induced by a circumferential V-notch in cylindrical specimens. The experimental results showed that the resistance to flow increased in both the metal and the alloy with either a decrease in test temperature or an increase in notch depth. The increase in resistance to flow, however, was accompanied by a corresponding decrease in ductility.

The precipitation-hardening stainless steels are now being widely used at tensile strength levels of from 175,000 to 200,000 lb per sq. in for aircraft construction where components attain moderately elevated temperatures. The steel known as 17-7 PH (17 per cent chromium, 7 per cent nickel, precipitation-hardening type) retains about 75 per cent of its room-temperature strength when it is heated to 800° F. The aircraft industry is now in urgent need of structural steels having even higher strength levels in order to meet the continuing demand for increase in speed and performance. The 17-7 PH steel can be heat treated and refrigerated to produce tensile strengths at room temperature in excess of 200,000 lb per sq. in, but this increase is accompanied by a decrease in ductility. As this type of stainless steel is relatively new, the mechanism of hardening is not well understood, and the identity of the hardening compound and the optimum conditions for heat treatment have not definitely been established. A study is now being made at the Bureau's laboratories, for the Wright Air Development Centre, of the effects of various combinations of heat treatments on the mechanical properties of this steel at room and elevated temperatures.

A knowledge of the factors governing the behaviour of refractory materials at high temperatures is important to the success of guided missiles, high-speed aircraft, and atomic reactors. For example, in the temperature range 1,500° to 2,500° C, the vapour pressure of solids and their vaporisation process under the influence of surrounding gases play a dominant role in determining the volume stability of the solid or its general usefulness as a structural component. Equipment has been constructed for carrying out vaporisation studies of inorganic refractory oxides using the Langmuir or weight loss technique. In this technique the vapour pressure can be determined by following the changes in weight with time of a solid of known area at some constant temperature. The vapour pressure of aluminium oxide has been determined in the range 1,000° to 1,350° C. With the recent installation of a 50 kW induction heater, this temperature range can be extended to 1,900° C.

Preliminary studies of the vaporisation process of aluminium oxide in the presence of various gases are under way. When the temperature of the material was raised to its melting point (2,015° C) in the Bureau's solar furnace, the alumina volatilised at such a rate that the molten material appeared first to boil and then to freeze as it drew upon its own heat to maintain the volatilisation process.

Studies of concrete at elevated temperatures have also been made. During the warm-up and take-off periods of jet aircraft, concrete aprons are often observed to deteriorate rapidly, even explosively as the result of extreme thermal shock. The studies, made for the United States Navy Bureau of Yards and Docks, and are concerned with finding means for preventing such failures. Results show that the primary cause of concrete spalling under rapid thermal shock is related to the total amount of unbound water present in the concrete. The rate and amount of water that is absorbed by concrete has been determined as a function of the mode of preparation, type of aggregate employed, and porosity of the hardened mass. Wide variations in both the rate and the amount of water absorbed and returned were observed, depending on the type of aggregate used. The available pore space or degree of consolidation in the aggregate has been found the dominant factor in the selection of a proper aggregate.

GLASSINESS

A new concept called a vitron has been proposed by the optics and metrology division of the N.B.S. for the study of the glassy state. The vitron is postulated as a submicroscopic stressed cluster of definitely arranged but slightly distorted elemental groups or cages (such as pentagonal dodecahedra) which, in turn, are composed of smaller and more nearly regular stable structural units (such as silicon-oxygen tetrahedra, in silica glass). As a system, these clusters tend to form at high melting temperatures and have some approximate noncrystal line symmetry, such as fivefold. Thus they are capable of limited but not extensive continuous growth. Such a cluster is definitely different from a crystallite, which can increase in size without limit.

The vitron concept has been applied to revise and reconcile existing theories of the structure of silicate glasses. The range of approximate order appears more extensive than formerly recognised and the randomness is relegated to the connective material that unites the clusters. According to this view, silica glass is a continuous network within which there are wide, approximately periodic modulations in the degree of regularity of the structural arrangement, and in existing stresses and force constants. The proposed model for silica glass is consistent, say the Bureau, with known data on density, differential diffusion of gases, interatomic distances, tensile strength, unusual thermal and pressure effects on volume, and internal friction at low temperatures. Evidence to support the theory is given by analyses of property-composition curves of solubility, chemical attack, volatilisation, specific volume, electrical resistance, and viscosity of binary alkali silicate glasses.

In the mineral products division, the molecular structure of many different types of glasses is being studied. It is hoped that determination of the basic principles will make possible the full development of the potential uses for glass, for example, the employment of glass as a structural material. To investigate

Continuing

Research and Development

this, a study is being made of the reaction of glasses to mechanical vibrations over a wide range of frequency, the presence of incidental minor constituents such as water in glasses at high temperatures, and the excess entropy of compounds in the glassy (vitreous) condition when compared with the same compound in the crystalline form.

Excess entropy is a measure of the extent to which the molecules in a glass are disorganised in comparison with the orderly crystal form. The disorganisation is a common feature of all glasses, and may be a controlling factor for many of the desirable properties peculiar to glasses. Excess entropies are being studied by calorimetric determination of the residual entropies of glasses at temperatures near absolute zero. Another technique compares the entropies of vaporisation of corresponding glasses and crystals.

RECOGNISED PATTERNS

The Bureau's high speed digital computer SEAC has now completed seven years operation. During this time it has been mainly used as a computational facility for problems originating within the Bureau. At the end of the fiscal year, however, it was changed to a research facility for data-processing applications and an engineering tool for studies of components and systems. Preparations for the new role have been under way during the past year.

Considerable progress has been made, say the Bureau, in a co-operative programme with the U.S. Patent Office for the mechanisation of patent search operations. A general purpose SEAC routine was developed for the search of topological structures, and applied to an element-by-element search of chemical structures. This routine has been used for sample searches of steroid patents. A comprehensive machine-search procedure was developed for general searches of patents pertaining to the composition of matter. New techniques of mathematics, logic, and linguistics that may be applicable to the solution of complex problems in information retrieval were explored, including the development of a machine programme to investigate the syntax of English sentences.

Under the sponsorship of the Rome Air Development Centre, automatic scanner input and output display equipment was designed and constructed to enable experimental simulation on SEAC of various character-recognition logics. The equipment makes it possible for a digital computer to accept automatically an image from a photograph or drawing into its memory and to reproduce a facsimile copy from its memory or to display the image as modified by internal processing. SEAC programmes have been written to determine experimentally various criteria for character and pattern recognition. These include routines to determine and display the centre of gravity of an input image and to determine the boundaries of black areas.

The foregoing paragraphs indicate the extent of the Bureau's investigations within a few of its fields of research. Investigations are in fact carried out in the following divisions: electricity and electronics, optics and metrology, heat, atomic and radiation physics, chemistry, mechanics, organic and fibrous materials, metallurgy, mineral products, building technology, applied mathematics, data processing systems, cryogenic engineering, and radio.

Engineering at Home

RADIAL ARM DRILL

In order to increase the usefulness of their bench drill stand, Wolf Electric Tools Limited, Pioneer Works, Hangar Lane, London, W.5, have introduced a radial arm that fits between the pillar and the base. A size is made for each of the four stand sizes. The arm consists of a casting with a pin to fix in the stand, the pin having a circumferential channel to enable it to be held by a screw. At the other end of the casting is a socket which takes and clamps the drill pillar. The arm gives a far greater work coverage for the drill, without the need to move the workpiece, and enables simple jig boring to be carried out.

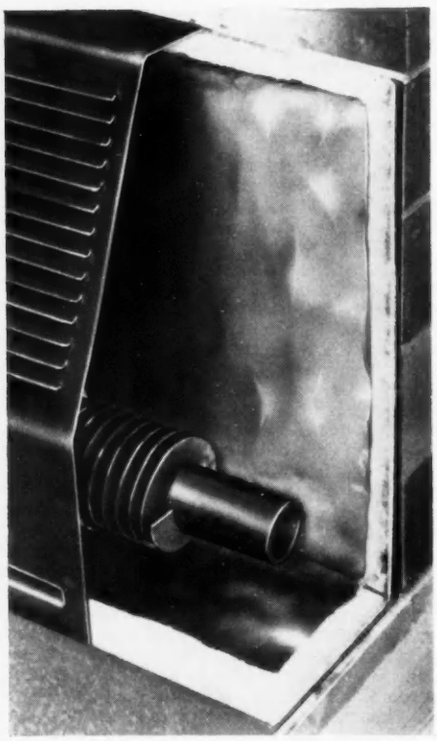
An arm interposed between the stand and the pillar, turns a fixed into a radial drill.

KITCHEN ELECTRICS

Revised editions, with new illustrations, of two publications of the British Electrical Development Association are now available. They are "Electric Kitchen Planning" (EDA 1715/RV), and "Cooking the Electric Way" (EDA 296E/RV). The first, a 32-page brochure, contains information not only on the design of kitchens for new houses but also on the improvements of existing kitchens, which can be made either as a whole or by instalments. The brochure, which is intended for distribution to architects, builders, and those buying a new house or having one built, contains sections on order in the kitchen, the problem of the large kitchen, dining-kitchen plans, the minimum kitchen, food storage, refrigerators, food preparation space, ventilation, washing up, hot water supply, home laundry, and kitchen lighting, including the use of fluorescent lamps.

The introduction points out that correct arrangement of appliances and cupboards in a kitchen is not a matter of individual preference, but should be based on the outcome of practical tests and experiments made to discover the most efficient and labour-saving layout.

"Cooking the Electric Way" is a four-page illustrated folder that outlines the construction and use of the electric cooker. Copies of both publications are obtainable from Electricity Service Centres or from EDA, 2 Savoy Hill, London, W.C.2.



The casing for the skirting heating element uses aluminium foil bonded on to insulating material to reduce heat losses.

SKIRTING HEAT

A skirting heating element using gilled tubing has been designed by Tomlinsons Limited, Oldham Road, Rochdale. The accompanying illustration shows the manner in which the element is mounted. Louvres on the slant face of the casing allow the egress of warm air; the back and floor of the casing are insulated to prevent undesirable heat loss. Aluminium foil is bonded to the face of the insulating material, which is mounted on a backboard drilled for fixing to the wall and floor. The heating element can be fed with low or high pressure hot water, or steam. Figures for the heat output of a low pressure hot water installation are given in the table.

Heat Output in B.t.u. per hour per foot run of Skirting Heating for Low Pressure Hot Water Installation

Room temp., °F	Water temp., °F				
	200	175	165	150	140
50	774	644	590	514	458
60	720	589	538	458	409
70	668	538	490	409	360

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